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EXPERIMENTS ON THE RADIATION OF CERTAIN HEATED GASES AND VAPOURS.

By J. Evershed, F.R.A.S.

THE recently published researches of Dr. Pringsheim (*Weidmann's Annalen*, 1892, No. 3) and Prof. Smithells (*Philosophical Magazine*, March, 1894) on the radiation of gases, raises an important question in connection with solar physics, namely, do the various gases forming the chromosphere and prominences, and the metallic vapours in which the photosphere is bathed, emit their special light radiations merely by reason of the high temperature to which they are exposed, or is there some chemical process involved; the luminosity being caused by what, from sheer ignorance as to the actual relations existing between matter and the ether, has been called "chemical luminescence," or the direct transformation of chemical energy into light? The latter view appears to have been adopted by A. Brester, and in his theory of solar phenomena he supposes a continual recombination of dissociated matter in the outer cooling layers, where other matter, condensed by the loss of heat into mist, no longer forms an obstacle to the free play of the chemical forces involved.

Or again, is the gaseous luminosity the result of electrical excitation, as other physicists have supposed, notably M. Deslandres, of the Paris Observatory? On this view the solar atmosphere is believed to be the seat of violent electrical disturbances, somewhat analogous to our terrestrial thunderstorms and auroræ but on a colossal scale, the prominences and those curious patches of bright calcium vapour which have been found to be so intimately associated with the faculæ on the solar disc, being regarded as local manifestations of electrical energy.

I propose in this article to bring forward evidence to show that whilst both chemical and electrical phenomena may, and very probably do, at times produce luminous effects on the sun, yet there is no necessity whatever to invoke the aid of either of these forces to account for the general illumination of the chromospheric gases and the ordinary prominences or the metallic vapours forming the "reversing layer" at the base of the chromosphere, and that there is strong reason for believing that these gases shine simply because they are excessively hot.

This, of course, was Kirchoff's original idea, but it seems to have been called in question of late years on account of the difficulty or impossibility experienced by experimentalists in inducing any gas or vapour to emit its own characteristic light radiation, or indeed any radiation, except when under the influence of the electrical discharge as in Geissler tubes, or of chemical forces as in ordinary flames; and it has always hitherto been through one or other of these agencies that the emission spectra of bodies has been studied in the laboratory. Quite recently, however, Prof. Smithells has carefully studied the glow produced when iodine vapour is heated, and has come to the conclusion that the light is simply the result of the high temperature. The vapour is in fact "red hot" just like any heated solid body, and it is this observation that has led me to make a series of experiments both with iodine and several other elementary gases and vapours, with the view of determining, first, whether the glowing iodine obeys Kirchoff's law, according to which the radiations of the heated vapour should have the same wave-lengths as are absorbed when white light passes through it, and secondly, whether this property of glowing is peculiar to iodine or is shared by other elementary bodies in a greater or less degree. After this I proposed to attack the problem of heated metallic vapours, and find an answer to the question whether they can be made to emit their characteristic light radiations by heat alone, the results of the researches of Dr. Pringsheim in this direction (above quoted) not appearing to me to give a decided verdict one way or the other.

The first experiments which I shall describe answer the first two questions quite satisfactorily, and as these are comparatively simple in their nature, and easily verified, it will be unnecessary for me to give an exact and detailed description of the apparatus actually employed; the only essential parts being a spectroscope, a Bunsen burner, and a piece of hard glass tube. I will, however, ask the indulgence of the readers of Knowledge when we come to consider the more critical experiments with glowing sodium, when it will be necessary to describe at some length the disposition of the various parts of the apparatus used, and the precautions taken to insure a valid result.

To determine, then, the first point—that is, the nature of the light emitted by iodine—a piece of hard glass tube, closed at one end, was strongly heated about the middle, and an image of the hot part was thrown across the slit of a spectroscope by means of a lens. A faint streaky spectrum, due to glowing opaque particles in the glass, was all that could be seen. A little iodine was then pushed into the tube, and immediately a bright glow filled the central bore. The spectrum showed no lines or bands, but appeared perfectly continuous, and similar to that produced by a red-hot iron wire, with which it was directly

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compared; no sign of resolution into lines could be seen, even with a highly dispersive train of five prisms.

Next, a ray of white light from the flame of a paraffin lamp was made to pass through the glowing tube and enter the spectroscope, after having suffered absorption by the heated vapour. The dark bands characteristic of cooler iodine were seen to be unchanged, and there was no sign of any continuous absorption. Thus, at the temperature of the experiment, iodine emits a continuous spectrum, and does *not* emit only those rays which it absorbs.

The second question, as to whether this curious phenomenon of a gas glowing with continuous light like a solid was a property special to iodine, was soon answered in the negative. Thus bromine was tried with exactly the same results, the glow being quite as conspicuous as that of iodine. Then chlorine was attacked, and after several unsuccessful attempts, this also was found to give a perfectly distinct glow of the same character as the others. The experiment was arranged as follows: chlorine from a generating flask was thoroughly dried by passing slowly through a long tube of calcium chloride; the dry gas was then passed along a straight piece of combustion tube heated strongly in the middle, this tube being connected with a larger glass tube, in which was placed a small reflecting prism, which allowed one to look along the central bore of the hot tube. With the room in which the experiment was performed made as dark as possible, and the eye screened from the light of the Bunsen, a faint but perfectly distinct glow was seen to gradually fill up the tube, beginning on the lower or hottest portion. With a spectroscope of very small dispersion and wide slit, the light appeared to be continuous, but it could only be traced between the positions of D and E of the solar spectrum, probably because of the greater sensitiveness of the eye for this region. There seems to be no more reason to suppose any chemical "luminescence" in the case of dried chlorine than in that of iodine or bromine.

After these experiments it was thought probable that all *coloured* vapours would be found to glow in the same way. Accordingly the vapours of sulphur, selenium, and arsenic were tried in an atmosphere of nitrogen, and all were found to glow faintly. Phosphorus, however, which gives a colourless vapour, appeared to give no light when free from every trace of oxygen.

The conclusion, therefore, is that all the elements which have been named, except phosphorus, can be made to emit light by the mere application of heat, but that probably in every case Kirchoff's law is entirely disregarded, the emission not corresponding in any way with the absorption spectra, and for this reason one cannot compare these luminous vapours with the chromosphere radiations, or with discontinuous radiation generally. It might still be contended that *line* spectra can only be generated by chemical or electrical luminescence.

My next endeavours were, therefore, directed to the production of metallic line spectra by heat, rigidly excluding chemical action. Sodium was the element chosen for the initial experiments; the powerful absorption produced by the vapour of this metal on yellow "D" light seemed, on Kirchoff's hypothesis, to give the best chance of success at the very moderate temperatures at my command.*

The apparatus used in this research, although apparently rather complicated, is really simple enough and can easily be rigged up by anyone at all familiar with chemical manipulations. It was designed with the object of excluding absolutely from the tube which was to be heated any gas that might be expected to act chemically on the vapour of the metal. In the diagram Fig. 1, A and B are two similar gas holders, improvised by inverting a couple of two gallon tins mouth down into larger iron vessels containing strong brine; guides are provided, so that the tins will float up perpendicularly when full of gas, a stopcock is soldered into the bottom plate of each tin (at the top in the position used), and a rubber tube leads from A to a couple of wash bottles (S′ S″) containing strong sulphuric acid; from S″ a long tube of hard glass (P) containing a little phosphorus leads into the drying tube (C), which is packed with calcium oxide and calcium chloride, the former to remove carbonic acid and the latter the last traces of water which may remain in the gas used after passing the sulphuric acid bottles. The drying tube connects on to the porcelain heating tube (H) through a metal T-piece, one end of the T having a glass plate carefully cemented in so that one may look along the inside of the heating tube, to which the T is connected by rubber tube tightened with wire, both connections being also buried in sealing wax. At the other end of H, which is covered in the centre by a fire-clay arch, is a second T of glass, one limb connecting with a glass gland or stuffing-box (G) with pierced rubber ends and filled with mercury. A long steel rod passes through the gland, the end being flattened to a spoon shape; this can be pushed along to the centre of H or drawn out past the entrance of the side tube of the T. This side tube is closed by a perforated rubber stopper, through which a small glass tube passes bearing a small reflecting prism cemented to the end, which is thus closed up; but in order to allow of the escape of the gases, so that a current may be set up in the apparatus, a hole is blown in the side of this tube near the prism. The outer end of the tube is connected by rubber tubing to another wash bottle (S‴) containing sulphuric acid, and from this again a tube leads to the gasholder B. Thus the entire apparatus forms a closed circuit and has no inlet or outlet. The gasholders have each a Y tube attached, one branch of the Y leading to the apparatus and the other connecting A with B by means of a rubber tube carrying a clip. The S at the foot of the diagram is a direct vision spectroscope, and L is a lens focussing the central parts of the tube H on to the slit of the instrument; both are attached to a strip of hard wood movable horizontally about an axis placed between the lens and the slit. This enables one to instantly push aside the spectroscope into the position shown by dotted lines, and observe the glowing tube directly.

The *modus operandi* of an experiment is as follows: First, one fills the gasholder A with some neutral gas containing no oxygen, or only a trace of that element, such as nitrogen or hydrogen, or ordinary coal gas. When full it is disconnected with the gas generator or gas main, as the case may be, and connection is made with the apparatus. Next, weights are put on the inverted tin until sufficient pressure is obtained to drive a current of gas through the wash bottles, drying tube, &c., into B, which will rise as A sinks. Then the Bunsen is lighted under the porcelain tube, which it presently heats up to a white heat for about two inches of its length. After sufficient dry gas has passed through, and all trace of moisture has gone, the current is stopped by closing the stopcock on A, and a small pellet of sodium is dropped into the steel spoon through the side tube of the glass T, the stopper with the inner tube and prism being removed for this purpose and quickly replaced; the current is then restarted in order to drive away any oxygen that will have diffused in by the operation, and at the same time the tube

* My heating outfit consists of a single Bunsen burner with an oblong aperture, supplied from a half-inch gas main, and giving a flat flame about six inches high and two inches wide.

P is gently heated by a spirit lamp flame until a small faintly luminous flame is seen, indicating combination of the last traces of oxygen with the phosphorus. After this has gone on a sufficient length of time, and the apparatus may be considered to be absolutely free from oxygen, water, or carbonic acid, the stopcock on A is again closed

Experiment II.—A pellet of clean sodium was placed in the steel spoon and the gas (coal gas) allowed to circulate, the phosphorus being heated. The line seen in Experiment I. was watched, and some time after it had quite disappeared the current was stopped, and the sodium pushed into the hot part of the tube. Instantly the central

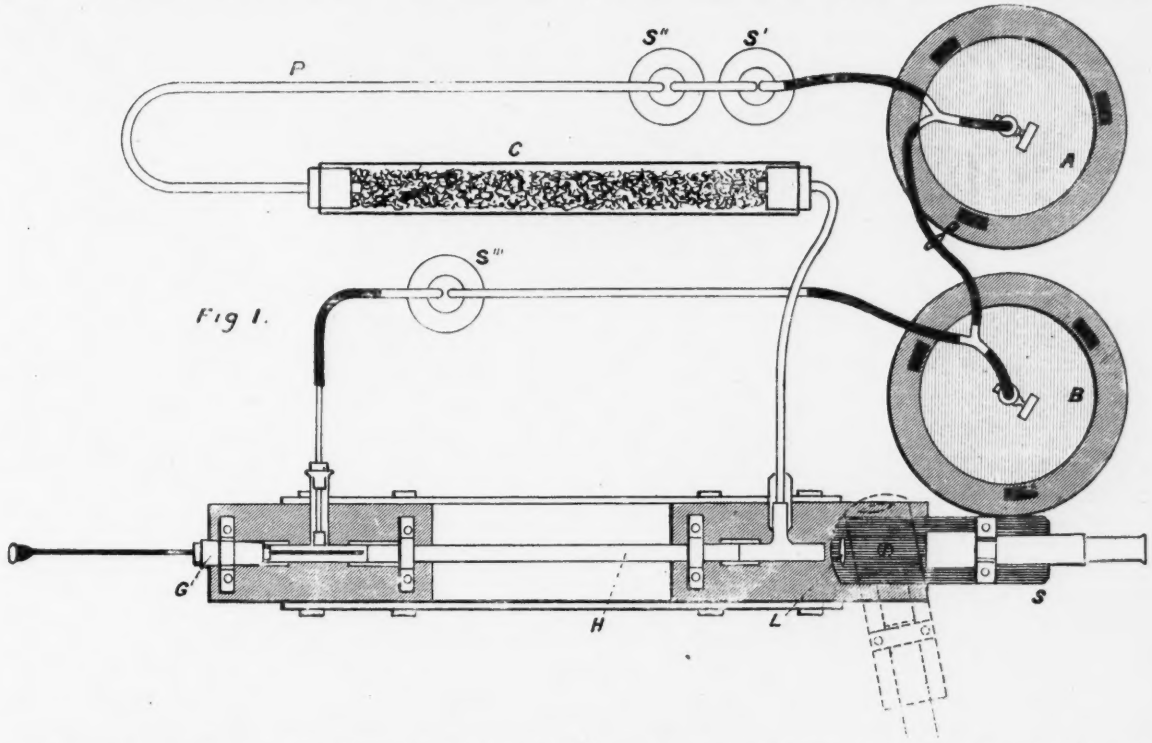

Fig 1.

and the steel spoon carrying the sodium is pushed into the hot part of the tube H, turned over, the sodium shaken out and again withdrawn past the entrance of the side tube. Now the tube carrying the prism is pushed down into line with the tube H, and the white flame of a paraffin lamp is placed close alongside the glass T, so that a ray of white light can be made to traverse the glowing vapour in H. One may now observe at will the absorption or emission spectrum of the glowing sodium by the simple operation of turning the lamp flame up or down.

I will now proceed to describe some of the experiments actually performed.

Experiment I.—With the porcelain tube strongly heated a slow current of coal gas, not specially freed from oxygen, was allowed to circulate in the apparatus, no sodium being admitted. A distinct and fine sodium line was visible in the spectroscope, which increased in brightness when a little air was mixed with the gas, but which gradually faded to invisibility when the phosphorus tube was heated so as to eliminate oxygen.

The explanation of this result is quite simple; the hydrogen combines with the trace of oxygen when it reaches the hot tube, and the "flame" so formed (which, however, is not visible as such except when a large quantity of oxygen is present) becomes tinted with sodium derived from the tube itself just as the Bunsen flame outside is tinted. This line, then, may be classed as the result of chemical "luminescence," whatever physical meaning may be ascribed to that expression.

bore of the porcelain was filled with light, which in the spectroscope was found to be perfectly continuous, but crossed by a very wide black line at D. Gradually the continuous spectrum faded, and as it became fainter the dark D line was seen to be bordered with a fringe of light on each side; and as the vapour became less and less dense, owing to the distillation of the sodium into cooler parts of the tube, the D line went through the changes represented in Fig. 2, in the order *a*, *b*, *c*, *d*, finally persisting as a rather wide* bright line in which a very fine dark line could usually be made out. But at any stage of the experiment, the dark central line could easily be extinguished by allowing a gentle current of gas to push back the cooler absorbing layer into the hotter regions. Now the question to decide was, whether this bright, broad, hazy D line was or was not the result of chemical activities.

Experiment III.—The sodium spectrum was examined as in Experiment II., but without heating the phosphorus, a considerable trace of oxygen, therefore, remaining in the gas. With the current stopped, the phenomena observed were the same as in Experiment II., but as soon as a slow current was allowed to impinge on the sodium by partly opening the stopcock on A, the *centre* of the broad bright line became much brighter, and could be seen projected on the adjacent continuous spectrum from the glowing sides of the tube.

* The dispersion of the spectroscope being insufficient to separate the components of the D line, it is evident that when a "wide" line was seen the two components of the pair were fused into one.

I consider that Experiments II. and III. prove that oxygen derived from the coal gas* used plays no noticeable part in the production of the bright line, for it is evident from the very great width of the line that the light is coming from a considerable thickness of very dense vapour, and it is impossible to believe that oxygen can be continually diffusing into the central dense regions without being arrested at the outer layers; and in proof of this, Experiment III. shows the actual effect of allowing oxygen to impinge upon the outer layer, the only result being to obliterate the absorption line and produce a central narrow line brighter than the broad line.

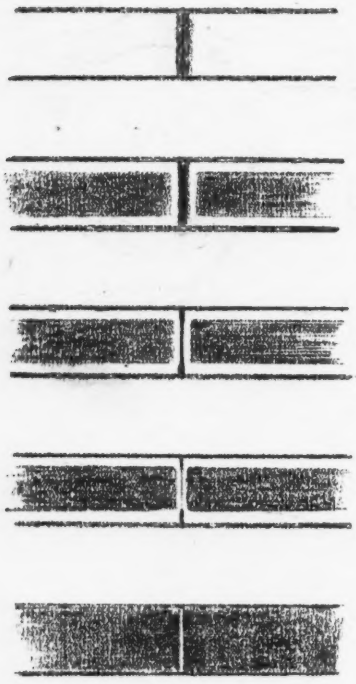

Fig. 2.—*a*. Continuous spectrum of dense sodium vapour with D absorption. *b*, *c*, *d*. Successive appearances after the continuous light has faded; the glowing sides of the tube give the bright edges to the spectrum. *e*. Ordinary flame spectrum of sodium with low dispersion.

There is, however, another possible source of chemical energy, namely, the porcelain tube itself, whence oxygen may be derived from the silicates of which it is composed; and some support is given to this supposition by the fact that after the experiments the tube is found to be considerably corroded, black silicon being deposited on the inside.

To test this I arranged another experiment as follows:

Experiment IV.—A short piece of iron tube, two and a half inches long and about three-eighths of an inch bore, was bevelled at the ends and fitted between two pieces of hard glass tube, the joints being ground to fit. This made a practically air-tight joint when the glass became soft by contact with the heated iron and was pressed close up, and it permitted a high temperature to be attained in the iron without the loss of heat by conduction which would ensue if the tube were made wholly of iron. Moreover, the temperature gradient being very sharp at the joints on account of the bad conducting power of the glass, there will only be a thin layer of the cooler absorbing vapour formed, through which one must always observe the bright-line phenomena.

With the tubes thus arranged the Bunsen was made to play only upon the iron, and when this had reached its maximum temperature the sodium was tipped out from the steel spoon as before. Now, if in the previous trials the luminosity was due to chemical action taking place between the sodium and the oxygen compounds of the porcelain, one ought in this experiment to find a striking difference in the intensity of the radiation. No such difference was, however, to be observed, the sequence of phenomena being exactly similar to that represented in Fig. 2. Some more experiments are contemplated with the iron tube, but I think enough has already been done to dispose of the theory that the light is caused by chemical processes.

In the foregoing experiments there still remains to be explained the continuous spectrum seen for a short time when the sodium is first volatilized. To investigate this the lamp and reflecting prism are brought into operation, and directly the sodium is pushed in, filling the tube with a reddish glow, the lamp is turned up and the prism adjusted. Then a most beautiful phenomenon is revealed; the glowing vapour is apparently opaque to white light, but projected upon it is seen a splendid violet light gradually changing to a fine blue as the vapour becomes more transparent, then greenish, and fading until finally no tint is seen—the heated vapour being at this final stage, to all appearance, perfectly transparent. Viewed with the spectroscope one sees, first, a bright band in the violet, the rest of the spectrum being dark except for the feeble continuous *emission* glow visible in the red and green, then a bright green band is transmitted, and later still a red band appears. These three beautiful bands of transmitted light gradually widen, the black absorption spaces between them becoming less and less in width and intensity; finally, the dark space in the blue fades away altogether, leaving only the band blotting out the yellow, which soon narrows down and becomes the ordinary D absorption line.

Now, by comparing the emission with the absorption at every stage, it was found that the continuous glow was brightest at first, when the absorption was greatest, and as the dark bands diminished the emission also faded, persisting, however, as long as the least trace of a dark band could be seen in the blue, vanishing when this disappeared.

The explanation of this result, I have no hesitation in saying, is as follows:—When the sodium vapour is above a certain density it gives the remarkable absorption spectrum described, but like iodine and other *coloured* vapours it emits, when in this condition, continuous light. I must here remark, however, that in performing this last experiment great care must be taken to have the apparatus dry and free from oxygen, and the metal must be pure and bright, otherwise the result is complicated by the production of a spurious glow due to solid particles of oxide forming a smoke-like cloud.

Here, then, we have found a connecting link between the radiation of the coloured vapours of the metalloids† and the line spectra of the metals. May we not, therefore, assume that all gaseous bodies are subject to the same general laws governing their light radiations, and that a sufficiently high temperature (coupled with not too great a density) is the only condition required to make each element strike its own characteristic light chord upon the ether. The bearing of these experiments on the solar radiation is obvious. Leaving alone the puzzling question as to how the vibrating molecules are enabled to impart their energy to the ether, we find it quite unnecessary to introduce further mysteries, implied by the term "luminescence," into the subject. The glowing calcium and hydrogen of the chromosphere are in all probability merely converting its enormous heat energy directly into

* These experiments have been repeated with nitrogen in place of coal gas, and with identical results.

† Iodine vapour at higher temperatures is said to emit a discontinuous spectrum, corresp nding to the absorption bands (*Salet. Spectroscopie*, p. 174); thus the relation is still closer.

light. In the absence of any knowledge regarding the radiation of gases under the enormous pressures and temperatures which must obtain in the deeper layers of the photosphere, it would be hazardous to assert that the continuous spectrum of these regions is in any way analogous to the continuous spectra of the comparatively dense vapours that I have subjected to experiment.

THE ANCIENT MAMMALS OF BRITAIN.

III.—The Lower Tertiary Period.

By R. Lydekker, B.A.Cantab., F.R.S.

BETWEEN the coralline crag and the Hempsted beds of the Isle of Wight, which belong to the middle portion of the Oligocene period, and are the next Tertiary deposits met with in Britain, is a long gap, owing to the complete absence of all representatives of the Miocene and upper Oligocene strata of the Continent. In consequence of this imperfection of the record, instead of finding a gradual transition from the mammals of the crag period as we pass downwards through the Miocene beds till we reach the Oligocene, we notice that the mammalian fauna of the lower Tertiaries of Britain is utterly unlike that of the upper beds, and shows not the faintest trace of connection with it. In place of deer, rhinoceroses, horses, and pigs we have, even in the highest beds of the lower Tertiaries, ungulate mammals of strange and unknown types, all of which belong to genera long since extinct, and differing widely in the structure of their low-crowned cheek-teeth from all modern mammals, although some appear to have approximated in external form to the tapirs and others to the pigs. Elephants and mastodons were entirely unknown, and the place of monkeys was filled by primitive lemur-like creatures. All the indications afforded by the flora and the molluscan life of the Oligocene and Eocene beds point to the conclusion that during those epochs Britain enjoyed a tropical or sub-tropical climate; and, in some respects, its fauna may be compared to that of Madagascar at the present day, although, of course, the genera of the mammals, and in many cases even the families were different. Indeed, of the land mammals inhabiting Oligocene and Eocene England, only two groups can be referred to genera that still exist, one of these being now relegated to the New World.

Lest the reader should begin to think that the whole of the strata whose fauna we have to consider in this part of our subject belong to nearly the same geological period, we hasten to point out the various groups into which they are divided, preparatory to the consideration of their fauna. The highest of the Oligocene beds in Britain are those forming the steep clay cliffs on the western side of the Isle of Wight, in the neighbourhood of Yarmouth, and termed the Hempsted beds, from a village of that name which is situated upon them. These belong to the middle portion of the Oligocene period, and have a fauna similar to that of certain beds at Ronzon, near Puy-en-Velay, in the Haute Loire. Next in descending order are the Bembridge beds of the Hampshire basin, whose fauna corresponds with that of the gypsum beds on which Paris stands, and which are consequently assigned to the lower part of the Oligocene; the beds of Hordwell, in Hampshire, and Headon, in the Isle of Wight, likewise belonging to the same great division. The clays of Barton, in Hampshire, which, like those next mentioned, unfortunately yield scarcely any mammalian remains, bring us to the upper portion of the Eocene period; while the older clays of Bracklesham, in Sussex, are assigned to the middle division of the same epoch. Better known than these is the London clay, forming the upper portion of the lower Eocene, and yielding several types of mammals; beneath which are the unfossiliferous Woolwich and Reading beds, resting on the chalk. Before proceeding to the consideration of the fauna of these various beds, it may be observed that mammalian remains are for the most part rare and fragmentary, and that for a full knowledge of the extent of the fauna of the period, and the structure of its component items, we have to depend largely upon the discoveries made on the Continent or in the United States, both of which are more favoured than Britain in regard to the preservation of early Tertiary mammals. In our survey of the fauna of all these beds, it will be more convenient to treat of the animals according to their zoological position, indicating the different horizons in which they severally occur.

At the present day, as explained in a former article, lemurs are chiefly characteristic of Madagascar, although likewise occurring in Africa, and also represented in south-eastern Asia, but in the Oligocene period they were abundant in Europe. One of these early lemurs was described from the Hordwell beds as far back as the year 1844 under the name of *Microchærus*, but it is only recently that its true affinities have been recognized. Not much larger than a squirrel, this creature approximated in the structure of its skull to the African lemurs known as galagos, but differed from all the existing members of the group in that the lower tusk was formed by the canine tooth and not by the first tooth of the premolar series. Still more different from any living lemur was the Oligocene *Adapis*, first described from France, and regarded as an ungulate, but subsequently recognized from the Hordwell beds. It differs from all modern lemurs in the presence of four pairs of premolar teeth in each jaw, and one of the species attained a comparatively large size, its skull measuring upwards of four inches in length.

In Madagascar lemurs are now accompanied by many kinds of insectivores, and it is, therefore, not surprising to find a member of that order in the Hordwell beds. This animal (*Necrogymnura*), instead of being allied to the Malagasy insectivores, appears, however, to have been related to the gymnura of Borneo, which may be described as a long-tailed hedgehog without spines, and therefore somewhat rat-like in general appearance. Civets likewise form an important element in the modern Malagasy fauna, and the Hordwell lemurs were accompanied by a member of that group assigned to the existing African and Oriental genus *Viverra*, which includes the true civets. With the exception of the opossums, this civet is the only terrestrial mammal from the earlier British Tertiaries which can be referred to a still living genus. The other early British carnivores belong to an extinct group known as the creodonts, which disappeared with the close of the Oligocene period, and differed from modern carnivores in that all their molar teeth were furnished with sharp cutting blades, instead of a single pair of cheek-teeth in each jaw being specially modified for cutting with a scissor-like action. In their dentition these primitive carnivores approximate, indeed, both to the insectivores and the marsupials, and they are undoubtedly far more generalized types than the existing members of the order to which they belong. While some were not larger than a fox, others fully equalled the dimensions of the largest bears. In Britain they are represented by one genus (*Hyænodon*) from the Hordwell beds, by a second (*Pterodon*) from the Bembridge limestone, and a third (*Argillotherium*) from the London clay. The last is, however, only known

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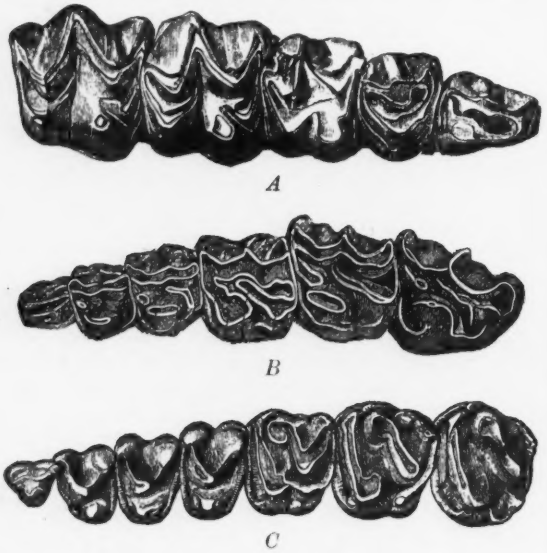
by an imperfect skull without the teeth, and may prove to be identical with one of the foreign genera.

Passing on to the hoofed order, one of the most interesting of the even-toed section is the *Dichodon* of the Hordwell and Headon beds, as being the only early British ungulate having the upper molar teeth with the four crescentic columns characterizing the true ruminants, to the ancestors of which group it was probably more or less closely allied. Connecting these early ruminant-like forms with the ancestors of the pigs is the *Hyopotamus* of the Hempsted beds, in which the upper molars were of the same general type as those of the anoplothere (represented in figure *A* of our illustration), although the whole form of the creature was more pig-like, the skull being long and narrow, with large tusks, separated by an interval both from the incisor teeth in front and the premolars behind. The *Hyopotamus* was doubtless a four-toed animal like the hippopotamus, but an apparently allied form from the Headon beds takes its name of *Diplopus* from the reduction of the toes to two in each limb. In the allied *Anthracotherium*, of both the Hempsted and Headon beds, the molars lose to a great extent the crescentic structure of those of the *Hyopotamus*; and in the gigantic *Elotherium* from Hempsted, and the smaller *Chæropotamus* of the Bembridge series, we come to ungulates having tubercular molars of the same general type as those of the pigs, although in the upper jaw they retain the five-columned arrangement characterizing the *Hyopotamus*, and have much squarer crowns than those of the pigs. There can, however, be little doubt that in this group we are very close to the ancestral stock from which the modern pigs and ruminants have alike originated.

On the other hand, the anoplotheres (*Anoplotherium*), which occur in the lower Oligocene of the Isle of Wight, and the upper molars of which are shown in figure *A* of the



A

B

C

Upper cheek-teeth of (*A*) Anoplothere, (*B*) Palæothere, and (*C*) *Coryphodon*. *A* is from the right, while *B* and *C* are from the left side.

accompanying illustration, belong to what is called an inadaptive type—that is, one which has died out without leaving descendants. These long-tailed animals, some of which reached the dimensions of an average-sized mule, were remarkable for the circumstance that the teeth formed a continuous series round the jaws, without any interruption by large tusks; and they were further peculiar among the group to which they belong in that in some cases there were three toes to each foot, although in others they conformed to the more normal type in having but two. In these animals the premolar teeth (two of which are shown on the right side of the figure) were only slightly compressed, but the nearly allied small and delicately built xiphodons take their name from the extreme compression and secant form of the teeth in question, in which respect they recall the modern chevrotains, or mouse-deer. Whether the xiphodons are really British is not quite clear, although a skull from the red crag, evidently derived from an older structure, has been assigned to them. The large size of the "tear-pit," or lachrymal fossa in front of the eye, has suggested for another member of this group, having teeth of the anoplothere type, the name of *Dacrytherium*, the English representative of the genus having been originally described from the Hordwell and Headon beds under the name of *Dichobune*.

This completes our list of the even-toed ungulates, and we proceed to notice the few early Tertiary British representatives of the odd-toed group, or those in which the toe corresponding to the human middle finger is symmetrical in itself and larger than either of the others. To this group belong the well-known palæotheres (*Palæotherium*), so abundant in the gypsum of the Paris basin and more sparingly represented in the Headon and Bembridge beds of Hampshire and the Isle of Wight. The structure of the cheek-teeth of a medium-sized representative of this genus is exhibited in figure *B* of the illustration; and in general form these animals somewhat resembled tapirs, although the neck was relatively longer, and there were but three toes to each foot. It was long considered that the palæotheres were on the ancestral line of the horse, but this view is now discarded, and they are considered, like the anoplotheres, to represent an inadaptive type. A much smaller animal described as *Anchilophus*, of which teeth have been found in the Bembridge limestone, is, however, either very close to, or actually on the ancestral line in question. Its upper molar teeth are not very unlike those of the palæotheres, but have the oblique cross-crests, narrower, less inclined, and separated by a more open valley. Although very common in the middle and lower Eocene beds of the Continent, the large genus of odd-toed ungulates known as *Lophiodon* are represented in Britain only by a single species from the Bracklesham beds. While their teeth are of the same general type as those of the palæotheres and *Anchilophus*, the upper molars differ in having the outer wall formed by sub-conical columns instead of flattened lobes, thereby resembling the corresponding teeth of the modern tapirs. Although most, if not all of these lophiodons died out without giving origin to any posterity, the case is very different with the nearly allied little *Hyracotherium*, originally described upon the evidence of an imperfect skull from the London clay at Herne Bay, since this genus is one of the earliest to which the ancestry of the horse can be traced. Thanks to the perfect preservation of specimens discovered in the United States, where they were long known under a totally different name, we now know that the hyracothere was a small four-toed animal, intimately connected with a still earlier five-toed type, while superiorly it leads on to the *Anchilophus* and certain allied Miocene continental forms, and thus to the modern horse. The hyracothere received its name from an idea that it was related to the existing hyrax; and it is a curious comment on the early history of palæontology to notice that the lower teeth of a second

species obtained from the lower Eocene sand of Kyson, in Suffolk, were at first supposed to pertain to a monkey.

If the palæontological riches of the United States have helped in the elucidation of the true affinities of the hyracothere, still more markedly is this the case with regard to the much larger ungulate originally described on the evidence of detached teeth from the London clay under the name of *Coryphodon*, in allusion to the strongly marked oblique crests surmounting their crowns. From nearly complete skeletons discovered in America, we know that the coryphodons, which were animals with somewhat the proportions of a bear, although furnished with a well-developed tail, differed from both the odd-toed and even-toed ungulates in having five toes to each of the very short and wide feet, and likewise in the structure of the feet themselves. The molar teeth, too, as shown in figure *C* of the illustration, are likewise quite different from those of any living member of the order, and are remarkable for the extreme shortness of their crowns. The nearest allies of these animals were the uintatheres of North America, distinguished by the presence of a large pair of tusks in the upper jaw,* and thetwogroups collectively constitute the order of short-footed ungulates.

One remarkable palate of a mandible from the London clay of Herne Bay, preserved in the museum at York, and described under the name of *Platychærops*, has given rise to some amount of discussion as to its serial position. It has been suggested, however, that it belongs to a peculiar group of mammals from the North American Eocene, which combine many of the characteristics of the ungulates, carnivores, and rodents. Of the latter order there are but small traces in the lower British Tertiaries; but some lower jaws from the Hordwell and Headon beds have been referred to the genus *Theridomys*, which is of common occurrence in the corresponding continental strata, and indicates an extinct family of the order. Whales are likewise rare, but from the Barton beds there has been obtained a skull belonging to the peculiar group of zeuglodonts, which are not improbably the ancestral types whence the modern toothed whales have been evolved. Unlike all existing members of the order, these extinct cetaceans had double-fanged molar teeth, whose compressed crowns had the edges surmounted by well-marked serrations; and, what is more remarkable, their bodies appear to have been invested with a bony armour comparable to that of crocodiles.

The last of the Tertiary mammals that we have to notice are opossums (*Didelphys*), remains of which have been detected both in the Hordwell beds and in the lower Eocene sand of Kyson. It is almost superfluous to add that opossums, which in Oligocene and Eocene times were widely spread over Europe, are now confined to America, where they attain their greatest development in that half of the continent lying to the south of the Isthmus of Darien. The relegation of the originally European genus to the New World is somewhat analogous to the banishment of the nearest living allies of the British Jurassic mammals to Australia, and is a well-marked instance of that gradual disappearance of the lower types of mammalian life from the western regions of the Old World, with the development of higher forms, which seems to have been such a characteristic feature in the evolution of the present faunas of the globe. Since we have already discussed the mammalian fauna of the Jurassic rocks of Britain in our article on "The Oldest Mammals," we may be excused from further reference to that part of our subject on the present occasion.

* See the figure in a previous article on "Tusks and their Uses."

INSECT SECRETIONS.—VI.

By E. A. Butler, B.A., B.Sc.

(*Continued from page* 198.)

THE secretions formed by beetles of which we have hitherto spoken are of use only to their fabricators, but we have now to consider a family of beetles whose products have for a long time been turned to account by human kind, and made an important article of commerce. This family is the *Cantharidæ* or *Meloïdæ*, some of the best known members of which are called blister beetles and oil beetles. The family is a very extensive one, containing more than a thousand species already described, which are world-wide in their distribution, though the majority have their home in tropical regions. Of this vast company we have only a very small sprinkling in Great Britain, a select group of nine species, distributed amongst three genera. Several of the nine are amongst our rarest insects, and not more than one or two are common. However, this small company contains the most useful insect of the whole family, the renowned Spanish fly, or blister beetle, *Lytta* or *Cantharis vesicatoria*.

Nothing more romantic than the life-history of the insects belonging to this family can be found throughout the whole range of insect life. It may be remembered that we have given details of two species of *Meloïdæ* in our articles on "Bee Parasites," viz., the common oil beetle, and the beetle named *Sitaris muralis* (see Knowledge, Vol. XV., p. 166). These may be taken as typical of the group, and the general history of a Meloïd may, therefore, be summarized as follows:—The eggs are extremely numerous, and on hatching produce very minute six-legged creatures, which have not merely the usual pair of claws at the end of each foot, but in addition a central pad, which looks like a third claw, whence these little beings are often spoken of as "triungulines" (three-clawed). They are also distinguished by possessing long bristles at the end of their bodies. They are very active, and their one business is to discover a suitable kind of bee, to whose body they may cling, so that they may be carried away by it, and obtain entrance into its nest. Here the little adventurer devours the bee's egg, and then becomes changed into a fat-bodied, short-legged creature, utterly unlike the little triunguline that produced it. The food of this clumsy larva—for larva still it is, notwithstanding its change of form—is the store that has been laid up by the bee for her own young. By the time this is finished, the larva has lost its legs and become barrel-shaped. But the cycle of changes is not yet complete; other phases have to be passed through before we arrive again at the point from which we started. In the next stage it is a six-legged grub again, similar to what preceded the legless barrel. After this it changes to an ordinary chrysalis, from which in due course the perfect beetle issues.

The great peculiarity in this marvellous history is the existence of two totally distinct types of larva, which succeed one another in time, viz., the active, running triunguline, which reminds us somewhat of the larvæ of those insects that have an incomplete metamorphosis, and the crawling caterpillar-like being, which is typical of the larvæ of those insects whose metamorphosis is complete. And here again there is a further complication, this form appearing twice, and its two appearances being separated from one another by an interval during which the creature passes into a form resembling the barrel-shaped chrysalis of a fly. Thus we seem to have in the total twice as many stages as are usually to be met with in the development of an insect.

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But our present concern is chiefly with the secretions produced by these insects. The oil beetle receives its popular name from the fact that, when handled, it causes a deep yellow, oily liquid to exude from between the segments of its body, and from the joints of the limbs, a proceeding which makes it a decidedly unpleasant insect to have much to do with. Oil beetles may be found in early spring, crawling slowly about among the grass of meadows, and beside footpaths. They may easily be recognized by their dull bluish-black colour, rough, uneven surface, and enormously large abdomen, which is only very partially covered at its base by the shrivelled and crumpled elytra, or so-called wing-covers, though there are no wings to cover. This ponderous body (speaking of the female insect) trails along the ground as the creature goes on its toilsome way, seeking a suitable place for laying its eggs. The yellow exudation is of an acrid character, and has the power of raising blisters, if applied to the skin in sufficient quantity. For this reason, oil beetles have been used in medicine, especially for veterinary purposes, the chief supply having been obtained from certain districts in south-west Russia. A German writer states that a century ago the oil of these beetles was used in central Europe as a remedy for hydrophobia, and in Sweden it is said to have been employed for the alleviation of rheumatic pains.

While one species of oil beetle (*Meloë proscarabæus*) is a common insect with us, and may frequently be seen in grassy places in early spring, its more important relative, the true Spanish fly, or blister beetle of commerce (Fig. 17), is very seldom met with in this country, though there have been occasions, notably in the year 1837, when it has appeared in profusion in certain localities. Scientifically it is known, as we have already said, either as *Lytta vesicatoria* or *Cantharis vesicatoria*, the specific name having reference to its blister-producing properties. It is a beautiful insect, of a shining green colour, and with a large square head. By its colour, as well as by the facts that its body is comparatively narrow and parallel-sided, and that the wing-covers lie side by side and are long enough to cover the body, it may be easily distinguished from the oil beetles with their bluish-black, stout, oval bodies, and short elytra, which slope sideways away from each other, and so reveal the abdomen between them. It is abundant in many places on the Continent, and the market was first supplied from Spain, whence it became generally known as Spanish fly.

Fig. 17.—Spanish Fly, or Blister Beetle.

Unlike the oil beetles, the blister beetles are arboreal in habits, frequenting a variety of trees, such as ash, privet, lilac, olive, &c. They appear about midsummer, and during the hottest parts of the day they descend from the trees, and that of course is the best time for securing them. Their presence is pretty easy to detect, for, apart from their brilliant colour, they emit a powerful scent. Indeed it is said that the characteristic substance to which they owe their valuable property is so volatile as to affect the air immediately around the trees, and thus make it an act of imprudence to sleep under those in which they are abundant. The active principle is called cantharidin, and many experiments have been made with a view to discovering in what part or parts of the insect it is produced, as well as whether or not its production is confined to the adult stage. In the year 1813 it was chemically examined by the French *savant* Robiquet, who obtained it from the beetles in the form of a white substance in flat crystals, which were found to be insoluble in water, but soluble in alcohol, ether, and other liquids. A chemical formula, $C_5H_6O_2$, has since been assigned to it. It has powerful vesicating properties, for the hundredth part of a grain, when enclosed in thin paper and applied to the lips, caused pain to be felt in about a quarter of an hour, and soon after little blisters appeared. When a salve was applied to these, the heat caused it to melt and run, with the result of carrying the vesicant with it, and thus multiplying the number of pustules, thereby increasing instead of allaying the discomfort.

The experiments of Beauregard were specially directed towards localizing the substance in the body of the insect, and they were carried out by making small plasters of different parts of the beetles and applying them to his own body. His main conclusions were that cantharidin occurred most abundantly in the blood and in certain parts of the reproductive organs in both sexes. Whenever any of the softer parts of the body, still wet and charged with blood, were applied to the skin, they soon produced blisters. Even the elytra, when separated from the living insect, and therefore still containing a small quantity of moisture within their tissues, were found to be capable of causing a similar result. They were applied to the arm by their inner surface, in which the skin would be thinner, and therefore the blood would be more easily able to affect the operator. The dry membrane which thus intervened between the vesicant and the skin of the arm of course retarded the process, but still, after the lapse of seven hours, a good blister was produced. When, however, the elytra were cut up in shreds, and dried with blotting paper, so that all moisture was removed from them, only a very slight effect was produced even by a prolonged application. Thus it was evident that the active principle was to be looked for in the juices of the wing rather than in its solid substance.

The strongly vesicating power of certain parts of the reproductive apparatus of course suggested that the function of cantharidin in the economy of the insect might be connected in some way with the reproductive process. But that such is not necessarily the case evidently follows from the fact that the insect possesses the property to a greater or less degree in all its stages, including those in which it is sexually immature. Even the eggs are possessed of the blistering power, though this perhaps is no more than might be expected, since the ovaries are strongly impregnated with cantharidin. In 1883, Beauregard took a portion of a freshly laid batch of eggs, and working them up into a paste with a little water, applied the little plaster so formed to his arm. After four hours, the smarting produced was sufficiently intense to lead him to stop the experiment. He therefore removed the plaster, and a few minutes after an enormous blister appeared on the spot, attesting the strongly vesicating property of the freshly laid eggs. In the larvæ the property was found to be much less intense. Ten larvæ, several days old, were crushed and made into a plaster, which was applied as before. Even after eight hours nothing more than a considerable inflammation was developed, and no blister appeared. When, however, a larger application of the crushed bodies of two dozen similar larvæ was made, a blister was produced after the lapse of the same time.

To collect the insects for medicinal purposes, a plan is adopted which closely resembles that known to entomologists as "beating." A large cloth is spread on the ground beneath the branches of the trees on which the insects are to be found, and then the branches are vigorously shaken, so that the beetles fall on to the cloth. Being but sluggish in their movements, they have little

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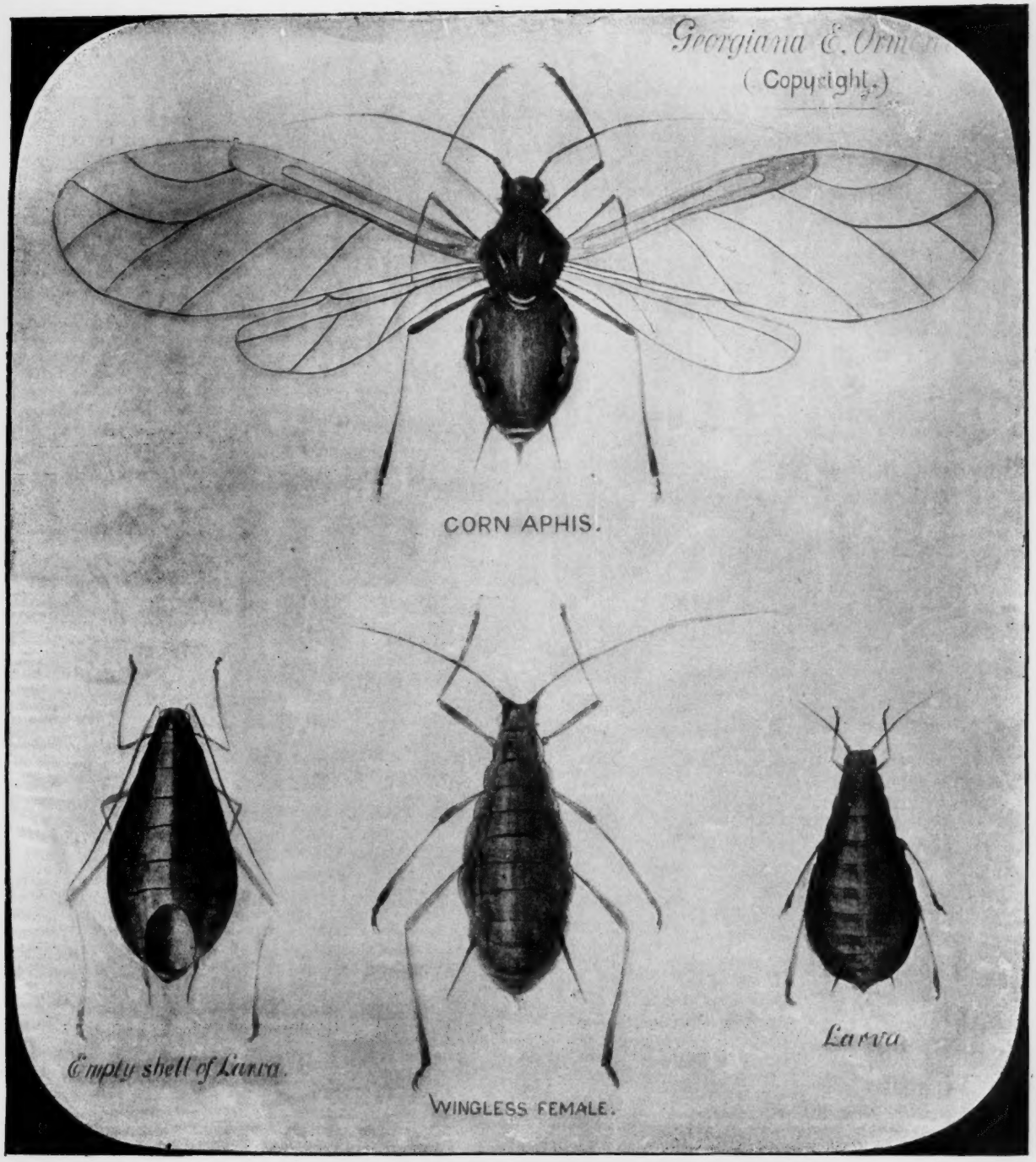

APHIDES DESTRUCTIVE TO GRAIN.

Showing winged and wingless forms, viviparously produced larva, and empty skin from which an internal parasite has escaped through the hole at the end. In all of these the two cornicles, from which honey-dew issues, will be observed pointing backwards at the hinder end of the body. From a lantern slide lent by Messrs. NEWTON, of No. 3, Fleet Street.

Direct Photo Engraving Co., 9, Barnsbury Park, N.

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chance of escape, and are easily gathered up as they fall. Of course they must be killed in such a way as not to damage their bodies, or in any way allow the valuable substance with which they are impregnated to escape, otherwise their commercial value would be impaired. Hence they are killed by means of a weak acid, either by plunging them into vinegar, or by exposing them to the vapour of acetic acid. The dead bodies, after being dried, are then stored.

But there are still difficulties to be contended with. As is well known, the dead bodies of insects are a peculiarly attractive bait to various small beetles, which are commonly known under the title of museum pests, and if these once obtain a lodgment amongst a store of dried Spanish fly, it is not an easy matter to dislodge them. It is vain to hope that the internal doses of cantharidin they are constantly administering to themselves by their ravages will have any evil effect, though this substance when taken internally by vertebrates appears to act as a dangerously irritant poison. When the museum pests attack the stores of blister beetles, the amount of damage done is measured simply by the matter actually devoured; for the cantharidin still remains uninjured in such parts of the damaged bodies as may be left, and for medicinal purposes it is by no means essential that the *dried* bodies should be perfect and entire, though, as we have already hinted, it is desirable that when freshly collected, and therefore moist, they should be in as perfect a condition as possible, lest exudation of fluid, and therefore loss of cantharidin, should take place. But the worst enemy to be encountered is damp, which, though it does not disintegrate the bodies, yet does far more harm than the above-mentioned devourers, since the characteristic properties of cantharidin are lost under its influence.

Some insects are gifted with the peculiar power of fashioning receptacles for their eggs, not out of extraneous and foreign materials, which would imply the exercise of a certain amount of intelligence and ingenuity, but from matter derived from their own bodies, and used in an involuntary and unconscious way. Special glands exist for this purpose, and open into the oviducts, so that the receptacle is formed within the body of the parent, and the insect never sees it till it is finished; hence the eggs are laid, not separately, but in sets, and, as it were, done up in parcels. This peculiarity is specially characteristic of certain groups in the order Orthoptera. In our own country, the cockroaches afford the best illustration of the practice, but in the tropics excellent examples are to be found in the various species of *Mantidæ*, or praying insects.

The egg-cases of the common household cockroach, or "black beetle" of the kitchens, may often be found lying about in the corners of cupboards, in houses where the insect is plentiful. The case is a reddish-brown, horny structure, about half an inch long, shaped something like a lady's handbag, and containing, as a rule, sixteen eggs, of which eight are placed on each side in perfectly regular order, lying parallel to one another. The eggs, of course, hatch within the case, and the young cockroaches issue from their birth-chamber at its sharp edge, *i.e.*, what would be the line of opening in the handbag aforesaid, where alone there is a junction. The material for these cases is supplied by a special gland appended to the reproductive apparatus, consisting of branched tubes, and called the colleterial gland, and the peculiar form is given to the case by the chamber on the walls of which the secretion is spread, and of which it therefore forms a sort of cast. When the whole structure is completed and properly equipped with its complement of eggs, it is still carried about by the mother for several days, during which time it may be seen protruding more or less from her body. It is finally deposited in some safe position, unless the creature is alarmed, when she will sometimes drop it at once.

Our wild cockroaches similarly form cases for their eggs, but as they are smaller than the domestic insect, the cases are much smaller too, and naturally, each species has its own peculiar form. Neat and shapely though these cases are, they are much surpassed in elegance by those formed by the exotic *Mantidæ*. These are large and predaceous insects with long and powerful fore-legs, which, when watching for their prey, they hold in front of them in the position that has been suggestive of an attitude of devotion, whence the name "praying insects," sometimes applied to them. The egg-receptacles of these insects (Fig. 18) are made of a clear, shining, pale yellowish substance, which is thin and semi-transparent, so that they look as if made of varnished paper or membrane. The surface is indented with a delicate tracery of reticulations, which throw it up into a series of minute rounded elevations. The cases are not left lying about on the ground, but are fastened by a little loop at the lower end to the twigs of trees and the stems of grasses.

Fig. 18.—Egg-case of a species of Praying Insect attached to grass stem.

The principle of construction is much the same as in the cockroach-bags, and so far as external appearances are concerned, may be paralleled, if one may borrow a familiar illustration from the pastry-cook, by that of the old-fashioned "apple turnover." As in that article of diet there is a cover whose continuity is unbroken save along a line on one side, where the two edges have been pressed together, and as the ingenuity of the cook seems often to have been expended in crimping and otherwise ornamenting the rim at this line of junction, so we find in the *Mantis* cases a raised line where the two edges meet, and a very pretty row of markings along it. Within, a partition, which looks as though made of congealed froth, runs across from the line of junction towards the opposite surface, but without reaching it, and the eggs are placed in regular order on each side of that partition, so that they are back to back, and remind one of the arrangement of the cells in a honeycomb.

It is an obvious suggestion that the purpose of these receptacles is to protect the eggs from hymenopterous parasites, many of the minuter forms of which are quite satisfied with the contents of a single egg-shell as the total provision for their larval life, so that they pass through their early stages parasitically within the eggs. But that the cases do not always accomplish this purpose appears from a specimen now before me, in which many of the eggs have been devoured by parasites, some of which have reached their perfect condition, and their shining metallic green bodies are still to be seen amongst the remains of the eggs to testify to the fact of their former ravages.

Taking now a brief mental review of the numerous and varied facts we have described in this series of papers on "Insect Secretions," we may point out one or two general conclusions to which they seem to lead. In the first place, we have the fact that during the lifetime of many insects there occurs a period in which the creature becomes quite helpless, not simply by passing into a torpid condition or a condition of suspended animation, but by the actual loss of its limbs, and with them the power of locomotion and therefore of escape from danger, and by the abortion

of its mouth organs and the consequent loss of the power to take food and sustain active life. Hence arises the necessity for special means of concealment and protection, that the race may not be exterminated when placed at so great a disadvantage with regard to its ever watchful and never resting foes. The necessary concealment or protection is afforded in many ways, occasionally by the use of foreign materials, but much more frequently by the production of a substance from within the creature's own body to serve as a cloak of invisibility or a chamber of safety. But as, in due course, deliverance from this chamber becomes necessary, it is equally imperative that another product should be elaborated for this purpose where mechanical means are not available.

Then, again, insects are usually very small animals in comparison with most of their assailants, and with smallness of size there is, of course, associated a corresponding helplessness against the larger and more powerful. And though in many cases their speed of locomotion is considerable when we take into account the size of the creatures concerned, yet the rate at which larger distances are covered is extremely slow in comparison with that exhibited by their pursuers, and hence escape by simple speed is usually out of the question; whence arises the existence of numerous secretions rendering them distasteful, or even physiologically hurtful as articles of food.

The development of the social instinct again, involving as it does the association of large numbers of the same species in one spot, necessitates the provision of suitable accommodation for the rearing of large quantities of young. And though this accommodation is frequently provided to a large extent by means of external and foreign matter, we see in the waxen cells of bees a product of the internal physiological processes of their own bodies used for this purpose. And even when the insects are not social, but only gregarious, there is, as we have just seen, provision for the large numbers of eggs produced, the provision on the part of the mothers of cases or sacs which shall supply the place of that maternal care and supervision which in the case of higher animals would probably be rendered.

The shortness of insect life is another important point. As few insects live for more than one season, and the period of activity of some of them lasts over no more than a few weeks, separated by an interval of many months from the next period of activity of the species, the continuance of the race is absolutely dependent upon the meeting and mating of suitable pairs during those few weeks. When the species is gregarious, or so abundant that large numbers are sure to be found within easy distance of each other, there is not likely to be much difficulty on that score. But when the species is solitary or scarce, and specimens occur only at considerable distances from one another, special aids seem to be needed to ensure the necessary pairings, and it may be that it is for such a purpose that some of the characteristic odours of insects exist.

Finally, in the case of the honey-dew of the aphides, none of the above heads seem suitable as an explanation of its existence. Here we have a material, not produced on certain special occasions, times of greater danger than usual, but continuously elaborated throughout life. A glance at the accompanying plate will show that the cornicles from which the drops issue are present in the larval forms as distinctly as in the nymphs or the adult insects. This fact, coupled with the above-mentioned difficulty of ranking honey-dew under any of the heads just enumerated, and with the statement made in a former paper, that no connection has been traced between the cornicles and any special glandular structure, lends support to the theory which makes it an excretion rather than a secretion; or, in other words, a substance elaborated to be got rid of rather than to be used. There is, further, the very exceptional circumstance, that it is a substance not merely got rid of by one kind of insect, but also eagerly sought after and used as food by another; and this fact is rendered more striking still by the immense differences, both in structure and life-history, that exist between the insects thus associated as producers and consumers, the aphides and the ants.

PHOTOGRAPHS OF THE MILKY WAY AND NEBULÆ.

By A. C. Ranyard.

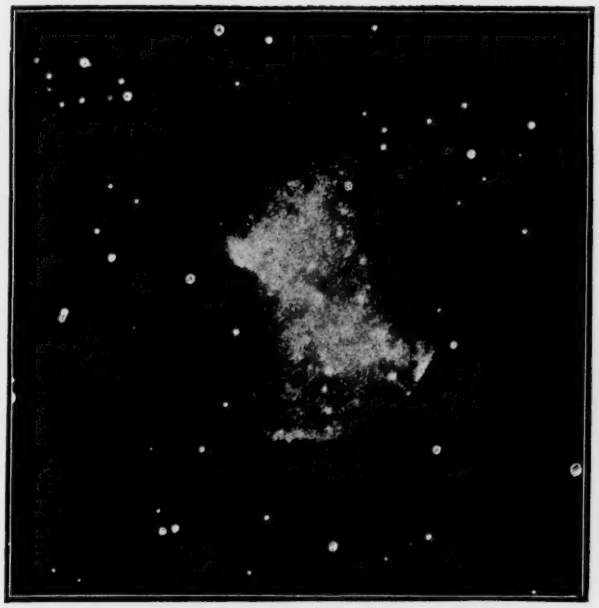
We are indebted to Mr. W. E. Wilson for another photograph of the Hercules cluster, taken with an exposure of only fifteen minutes. The photographic action has not gone far enough to blot out and drown with nebulosity the prominence forms and strings of stars shown in the Henry and Lick photographs, reproduced in the April and May numbers of Knowledge for 1893. The sharpness and clear definition of these details, shown in Mr. Wilson's photograph, speaks very highly for the optical perfection of his reflector, which was made for him by Sir Howard Grubb. Even the photographic reproductions, which I am able to put before the readers of Knowledge, will well repay a careful study and comparison with the longer exposed photographs reproduced in the last number of Knowledge, as well as with the Henry and Lick pictures. It seems to me, from a study of the photographic prints sent by Mr. Wilson, that there is ample evidence of more than one dark prominence-like structure, indicating that light-absorbing material, as well as luminous matter, is ejected in streams from the central region of the cluster, and that in rushing outward it experiences resistance. The photograph also shows the nebulous ligatures joining lines of stars, referred to in the last number, and confirms the suspicion that many of the star discs are not circular, but are elongated in the direction of the chain of stars. They appear more like patches of brighter nebulosity with a sensible area than like star discs.

The photographs of the dumb-bell nebula, also sent by Mr. Wilson, are well worthy of study. The dark gaps in the nebulosity are as interesting as the bright structure. This nebula seems to have a bright stellar nucleus, and a curious stratum of brighter nebulosity at the outside. With longer exposures the dumb-bell form is lost, and the nebulosity extends so as to fill an elliptic area.

We are indebted to Dr. Max Wolf, of Heidelberg, for the photograph of the region of the Milky Way about β Cassiopeiæ. The silver prints from the original negatives which he has sent over show some enormous dark branching structures outlined by stars. The collotype reproduction does not show them nearly as well as the silver prints, but there can be no doubt about their existence.

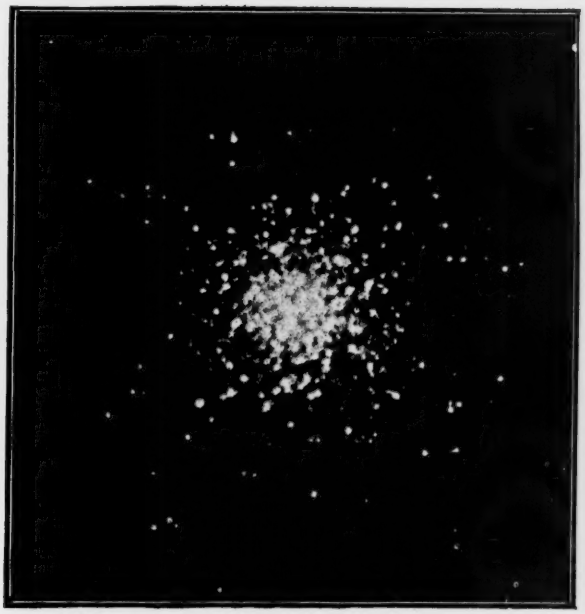
Notices of Books.

A Naturalist on the Prowl or in the Jungle. By E. H. A. (Thacker & Co., London, 1894.) E. H. A. has already attracted very favourable public notice by his lively books, "The Tribes of my Frontier," and "Behind the Bungalow," which introduce the reader to the human surroundings of an Anglo-Indian's life. In this book he brings before us



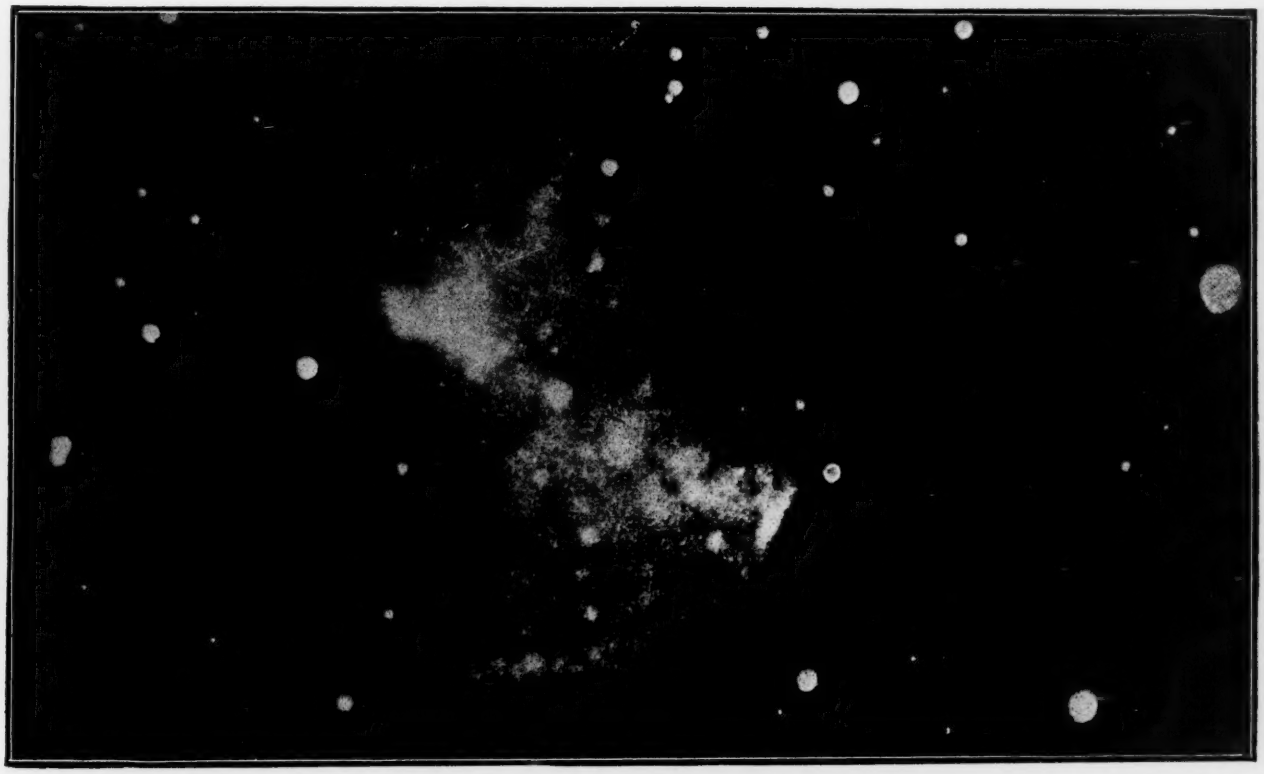
THE DUMB-BELL NEBULA.

From a Photograph by Mr. W. E. Wilson, taken August 6th, 1894, with an exposure of twenty minutes.



THE CLUSTER IN HERCULES (13 MESSIER).

From a Photograph taken 2nd September, 1894, by Mr. W. E. Wilson, with an exposure of fifteen minutes.



THE DUMB-BELL NEBULA IN VULPECULA.

From a Photograph by Mr. W. E. Wilson, with a reflector of two feet aperture, and focal length of ten feet six inches. Taken 6th August, 1894, with an exposure of twenty minutes.

Direct Photo Engraving Company, 9, Barnsbury Park, N.

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in the same interesting and lively style the habits and manners of Indian birds and beasts, insects and crabs.

For a natural history book it is very light literature, but no one can read it through without picking up a great many facts which are set out with care and precision, and they are facts of a kind which only a naturalist who has himself observed in the field and jungle can supply to his readers. There are here and there a few thoughtful remarks and philosophical speculations, which appear in the midst of rather forced jokes and stories of the exaggerated type which have been described as the new humour; but anyone who has the patience to bear with the humorous, or intendedly humorous, passages will be well repaid for reading the book through. There are some eighty excellent illustrations prepared by Mr. R. N. Sterndale, author of "The Mammalia of India" and "Denizens of the Jungle." As a specimen of the forced humour which E. H. A. too frequently introduces, one may quote his description of hot weather in India:—"The weather is getting warm. This is, perhaps, not expressive enough, what I mean is that the atmosphere is getting like that which we may imagine to prevail under a pie-crust when the pie is in the oven; of course, I am writing from the coast. Up country, on the plains of the Deccan, the atmosphere of the oven outside the pie furnishes a better illustration. . . . Anything like a long walk in the morning endows you with a thirst which will not leave you all day. It is not a wholesome thirst either, not a demand of nature for refreshing forms of moisture, but a kind of glutinous thickness such as troubles the throat of the office gum bottle." But, nevertheless, the book contains eloquent passages. E. H. A. tries to induce his readers to observe nature rather than to aim at becoming a naturalist, whose sole object is to collect specimens and name them. Beware, says he, of the snare which lurks under the intoxicating pleasure of collecting, and set a watch upon yourself lest you degenerate into a collector, and cease to be a naturalist. As soon as you begin to feel that a rare bird or butterfly is not so much a bird or butterfly to you as a "specimen," you have caught the distemper, and must take measures to check it. The best remedy I know is to set aside one day in the week for a sabbath of peace and goodwill, on which the instruments of death must be laid aside, and an amnesty proclaimed to all creation. Then you may move among living things with heart free from guile and mind undisturbed by stratagems, and you will note many things in them which you never saw when you were scheming to compass their destruction. E. H. A. has a theory that the noises made by insects and tree frogs, and other living things whose voices fill the air of the tropics with a continual babel of sound, are made simply because the little creatures are happy, and not from any sexual impulse. His theory is that when an animal is well and happy, there is an overflow of nervous energy. The wagtails and redstarts let it off by shaking their tails, and the crickets and the frogs let it off in noise. "Do you think," says he, "that man is the only animal which feels the monotony of doing nothing?" All living things feel it till you get so low down in the scale of life that they can scarcely be said to feel anything at all.

Corea of To-day. (Nelson and Sons, London, 1894.) Most of the matter in this little book has been extracted from a larger book by G. W. Gilmore, who went to Corea as a teacher in the Royal College, founded by the Corean king in his capital for the education of the sons of the Corean nobles. Mr. Gilmore is an expert photographer, and some excellent reproductions of his Corean photographs are given. When Mr. Gilmore arrived in Corea he found that he and his co-teachers occupied an enviable position in Corean eyes, as men who had taken rank in a great foreign examination. In other words, they were looked upon as "gentlemen" in the Corean sense, and were expected to keep up the dignity of their position. Soon after their arrival a soldier was sent to each teacher, by order of His Majesty, to be a sort of personal attendant and messenger. If Mr. Gilmore went out shooting, the soldier in attendance always took the gun and insisted on carrying it till they reached the hunting ground. The distress of his soldier was quite pitiful when he took out two pieces, a shot gun and a rifle, so that he had to submit to one of them being carried by Mr. Gilmore. On another occasion one of the teachers took to gardening, and began to use a spade, when his attendant ran up and tried to take the spade out of his hands, remonstrating with him for doing coolies' work. The common people are extremely polite, and Mr. Gilmore describes them as always showing great kindness and distinction to foreigners. In summer the Coreans have a peculiar device for keeping cool. Next to the body they wear a framework made of split bamboo woven in fancy designs. This is made so as to be supported from the shoulders, and holds the clothes away from the person, so as to permit the air to circulate freely. Many interesting details are given with regard to the fashions of the people, their manners and customs, religions and superstitions, and the extraordinary absolute monarchical government, which seems to be entirely independent and uncontrolled by the will of the common people. Mr. Gilmore seems to have had exceptional opportunities of observing the Corean people. He tells his story well, keeping up the reader's interest from the first page to the last of his little book.

The Earth; an Introduction to the Study of Inorganic Nature. By Evan W. Small, M.A. (Cantab), B.Sc. (Lond). (Methuen & Co., London, 1894.) Taken as a whole, this is an excellent little manual for the general reader, as wel as for the student who selects it as a text-book in physiography. No book which ranges over so wide a series of subjects can be expected to be above all criticism. Thus, in giving an account of the nebular hypothesis, Mr. Small says: "The cloudy patches of light in the heavens known as nebulæ (whose spectra, as shown by Huggins in 1864, consist of a few bright lines, indicating glowing gaseous matter) represent, according to this theory, the earliest stage in the process of world formation, and in the great nebula in Andromeda (as shown in a photograph taken by Mr. Isaac Roberts of Liverpool) we have an actual instance on a very large scale of some such process of cosmical evolution as is pictured in Laplace's theory. In this photograph we see a large bright central mass, surrounded by a series of successive rings of bright material (the outer ones becoming fainter), separated by dark spaces." Mr. Small is evidently not aware that the large majority of nebulæ do not give a gaseous but a continuous spectrum, and that the streams of matter about the Andromeda nebula are by many observers believed to be spirals and not circles. There is certainly no evidence in the photographs of ring within ring of nebulous matter, and the nebulæ surrounded by spiral streams of nebulous matter are very numerous.

A Journey in other Worlds. By John Jacob Astor. (Longmans, Green & Co., London, 1894.) Mr. Astor takes his readers to an imaginary Jupiter and an imaginary Saturn, and gives them a historical sketch of our own world in A.D. 2000. The value of such flights of imagination depends to a large extent on the knowledge displayed by the imaginative guide, and on the way in which he makes his narrative appear probable and consistent with known facts and received scientific theories. Mr. Astor

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supposes Jupiter to be passing through a carboniferous or Devonian period, such as existed on our earth, but neither the pictures nor the text exhibit much geological knowledge, and his knowledge of astronomical facts is still more meagre.

The following books have been received for notice:—

Knowledge through the Eye; or How to Illustrate Science and other Lectures by Means of the Optical Lantern. By Alfred P. Wire and G. Day, F.R.M.S. (George Philip & Son.)

The Romanes Lecture, 1894—*The Effect of External Influences on Development.* By August Weismann, M.D., Ph.D., D.C.L. (Henry Frowde.)

The Seismological Journal of Japan. Vol. XIX., 1894. (Yokohama.)

British Rainfall, 1893. By J. W. Symons, F.R.S., &c., and H. S. Wallis, F.R.Met.Soc. (Edward Stanford.)

Catalogue of Works on Astronomy, Magnetism, and Meteorology. (Dulau & Co.)

The Royal Natural History. Part 10. (F. Warne & Co.)

Things New and Old; or Stories from English History. By H. O. Arnold-Forster. (Cassell.)

The Molecular Tactics of a Crystal. By Lord Kelvin, P.R.S. (Clarendon Press.)

The Sportsman's Handbook to Practical Collecting and Preserving Trophies. By Rowland Ward, F.Z.S. (Rowland Ward & Co., Ld.)

The London Matriculation Directory, 1893-4. (Univ. Corr. Coll. Press.)

Some recent Evidence in favour of Impact. By A. W. Bickerton. (Wellington, N. Z.: Samuel Costall.)

Venice. By Alethea Wiel. (T. Fisher Unwin.)

The Journal of the British Astronomical Association. Vol. IV., No. 9. (Eyre & Spottiswoode.)

Revolving Orrery. By J. C. Parvin. (G. Philip & Son.)

Theophrastus of Eresus on Winds and on Weather Signs. By Jas. G. Wood, M.A., LL.B., F.G.S., and Edited by G. J. Symons, F.R.S., F.R.Met. Soc. (Ed. Stanford.)

Syllabus of the Municipal Technical School, Manchester, for Session 1894–5.

Meteorological Observations for 1893, *made at Rousdon Observatory.*

Fertilizers and Feeding Stuffs. By Bernard Dyer, D.Sc., and Notes on the Act, by A. J. David, B.A., LL.M. (Crosby Lockwood & Son.)

Proceedings of the Society for Psychical Research. Part 26, Vol. X. (Kegan, Paul & Co.)

Catalogue of the Michigan Mining School, 1892–4, *and Announcements*, 1895–6. (Houghton, Mich.)

Newfoundland as it is in 1894. By the Rev. M. Harvey, LL.D., F.R.S.C. (Kegan, Paul & Co.)

The Royal English Dictionary. By Thos. T. Maclagan, M.A. (T. Nelson & Sons.)

Programme, &c., of Technological Examinations of the City and Guilds of London Institute, Session 1894–5. (Whittaker & Co.)

Illustrated Catalogue of Telescopes and Accessories. (E. G. Wood.)

Mr. W. H. Hudson gives a depressing list of "Lost British Birds," including the crane, white spoonbill, great bustard, bittern, marsh harrier, hen harrier, red night reeler, great auk, and avoset. This, he says, is the result of the efforts of "sportsmen" and the unprincipled collector.

Letters.

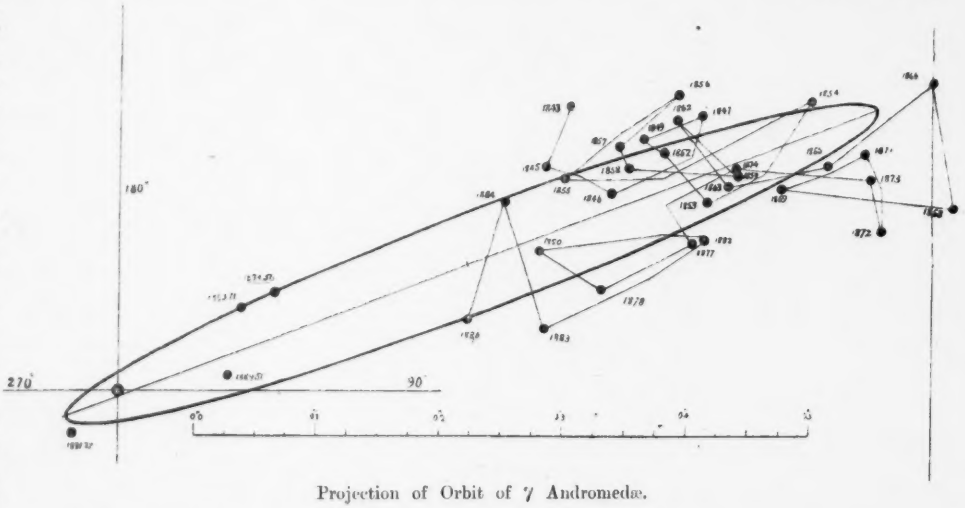
[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

ORBIT OF γ ANDROMEDÆ.

To the Editor of Knowledge.

Dear Mr. Ranyard,—. . . . . Barnard has this year got a set of measures of γ Andromedæ with the thirty-six inch. I have put his last position on my original diagram of the apparent orbit, and enclose a photograph of it. As you will see, Barnard's place fits in beautifully with the ellipse already indicated. Yours very truly,

S. W. Burnham.



Projection of Orbit of γ Andromedæ.

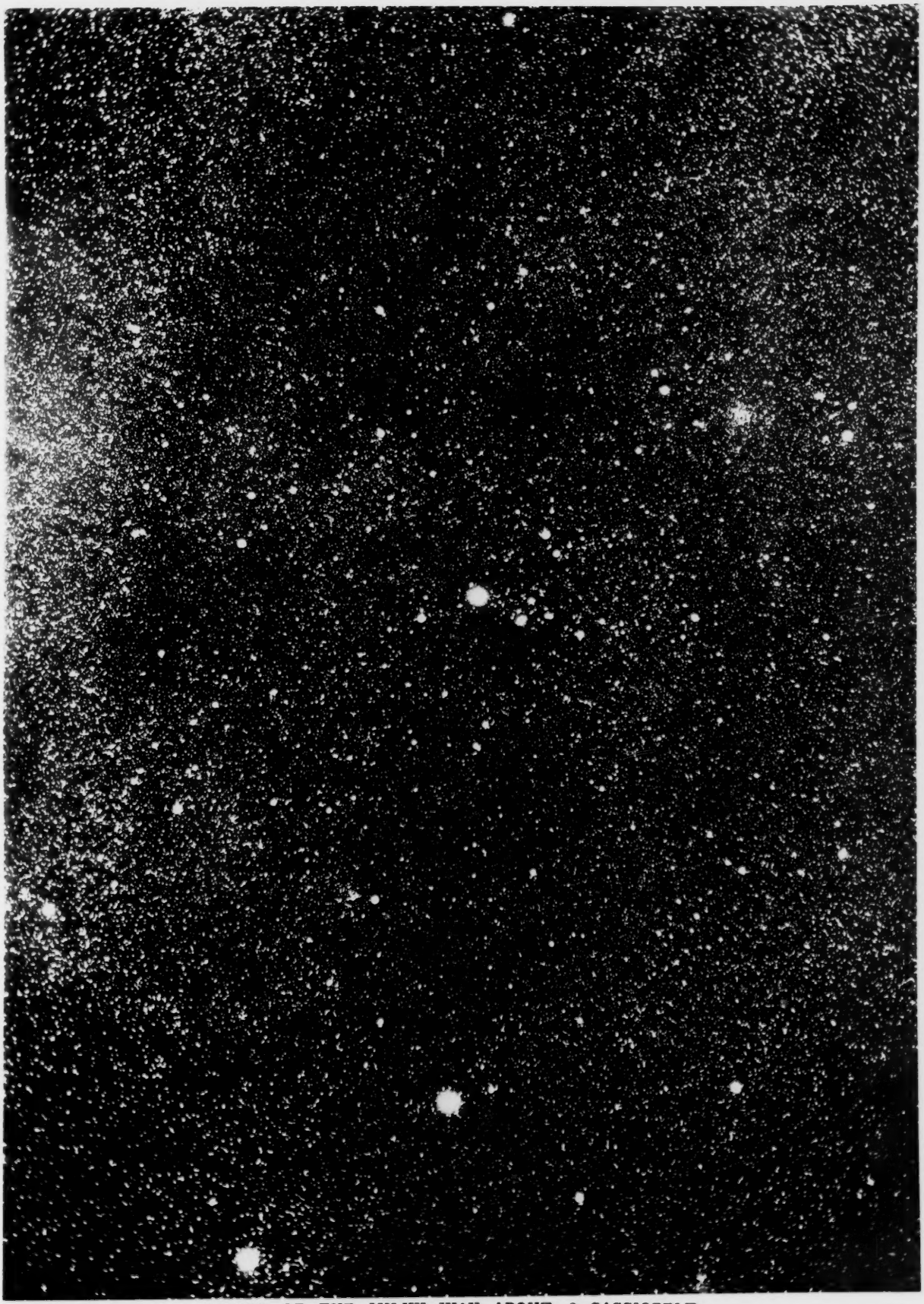
THE LEONID MAXIMUM.

To the Editor of Knowledge.

Sir,—I think the answer to the question asked by Mr. A. Collison, on page 135, has not been fully given. What he really wishes to know is the time that the maximum of the shower will take place. The earth will be in the same longitude, 1899, November 13th, 13h., as it was in 1866, November 13th, 13h. 9m., when the shower reached its maximum that year; but does not the time of maximum alter from year to year? I suppose it will be possible to make a better forecast nearer the time. Is not 1900 just as likely as 1899 for the greatest shower?

Yours respectfully,

West Hendon House, T. W. Backhouse.
Sunderland, 25th September, 1894.



REGION OF THE MILKY WAY ABOUT β CASSIOPEIÆ.

From a Photograph taken by Dr. MAX WOLF, with an exposure of 15h. 19m., made on December 30th and 31st, 1893, and January 1st and 2nd, 1894.

Direct Photo Engraving Company, 9, Barnsbury Park, N.

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ON THE ORIGIN OF THE GOLD OF QUARTZ VEINS.

To the Editor of Knowledge.

Dear Sir,—Although the article by Mr. Henry Louis "On the Origin of the Gold in Quartz Veins," following one of mine on the same subject, does not call for a reply from me, since it is a very fair statement of another view of a matter on which widely different opinions are inevitable and legitimate, yet some of the observations in this interesting article suggest my adding a few words to what I have already written, in further elucidation of one or two points that were perhaps treated too briefly.

The hypothesis I endeavoured to state is not by any means essentially a "descensionist" one, since it allows of lateral transmission of solutions into incompletely filled up fissures, as well as entrance from above, for it derives the mineral matter of vein-stuff from the adjacent massive rocks—the rocks, in fact, traversed by the veins.

The volcanic evidence adduced against a plutonic origin for the gold of quartz veins may certainly be called negative, but from the nature of the case it has an important positive value, which is not lessened by one or two exceptional instances to the contrary. It is not disputed that some gold may exist at plutonic sources, and may therefore occasionally be thence brought to the surface by volcanic action, but it is the source of the great bulk of the gold which exists in quartz veins that is the question to be determined. A proportionally large space was occupied by this volcanic evidence because, so far as I know, it is evidence that has not been brought into the controversy by any other writer on the subject, therefore it seemed to deserve conspicuous notice.

The instances of Steamboat Springs and Sulphur Bank do not appear to me to have any contrary weight, for they do not afford examples of mineral matter brought up from deep-seated sources by volcanic action, but merely of such matter brought from the adjacent rocks by hydro-thermal action, exactly in accordance with one of my postulates. And with respect to the Mount Morgan gold-bearing quartz, even if it be the production of an old geyser, it is but siliceous sinter similar to that deposited around the geysers of the present day, and that is all derived by hot water from rocks near the surface which, though heated by volcanic action, may not be volcanic rocks. A geyser, therefore, although its intermittent energy is doubtless due to volcanic action, is not volcanic in the sense of bringing to the surface mineral matter from the deep interior.

There is another point which seems to require explanation. The precipitation of metallic gold from a soluble salt is from soluble salts of gold in the sea that I suggested would be the result of the action of dead organic matter at the sea bottom, and would consequently only affect the amount of auric solution in the lowest water-stratum, and so, although the precipitation would be continuous in consequence of convection, it would only very slightly lessen the aggregate amount of gold in the entire oceanic volume of water. Thus the existence of a generally diffused solution of gold in the sea is not inconsistent with the precipitation supposed.

I am glad to find Mr. Louis so much in agreement with me, especially as to gold being taken into quartz veins by the same agency as the silica, and that the sedimentary rocks themselves contain gold. This last fact is to my mind a most pregnant one, since the materials of these rocks are deposited matter. I know of no other source for that deposited matter than the contents of the sea, and hence I am inclined to credit the sea-water with giving to its more bulky sediments the extremely small amount of gold they contain, even when their auriferous vein-quartz is included.

Respecting the final stage in the series of operations constituting the hypothesis I ventured to formulate, I may perhaps say that the separation of minerals by the segregation of their molecules from other associated mineral matter is such a common geological phenomenon that its employment to account for the separation of gold, and its consequent presence in the metallic state in quartz veins, does not seem to me to be unwarrantable.

As Mr. Louis justly says, the subject is a difficult one, but it has certainly greatly advanced in my own recollection. In the days of Murchison and Forbes the igneous origin of gold held the field, and the latter of these two high authorities (I know from personal intercourse with him) held that now almost obsolete theory even more strongly than would appear from his writings. We may, therefore, confidently hope that further investigation and further consideration will not fail to yield a satisfactory solution of this interesting, if at present somewhat obscure, problem.

Yours faithfully,

J. Logan Lobley.

THE PERIODICITY OF THE SOLAR SPOTS AND ITS CAUSE.

To the Editor of Knowledge.

Dear Sir,—Probably it is hardly necessary to say that I am acquainted with Prof. Rudolf Wolf's labours on the solar spots, and I am certainly not prepared to reject the evidence he has brought forward of occasional irregularity in their periodicity. But it seems to me that this is perfectly consistent with my theory, that the periodicity of spots, which has only been noticed during the present century, is due to a swarm of meteors revolving round the sun in an elliptic orbit, with a period equal to the average period of the spots. Unquestionably, spots are also produced in other ways, or by other bodies than this supposed ring. Now these may sometimes come in a considerable number a little after a time of regular maximum, which would protract that maximum, as in 1883; or, on the other hand, near a time of regular minimum, when they would cover and mask its occurrence. The effect, indeed, would be somewhat similar to that of tidal action in the Mediterranean, which can only be evidenced by a long course of observation, being continually masked to appearance by local causes of rise and fall connected with the weather.

Yours faithfully,

Blackheath, W. T. Lynn.

September 4th, 1894.

[A meteor swarm which would, on its approach to perihelion, give rise to an appreciable solar tide, or to a difference of pressure in the vapours beneath the photosphere, would need to be of such mass that one would expect to find some trace of its perturbing influence in the motions of the planets; and, in order to account for the irregularities of Dr. Wolf's sunspot curve, we should need to conceive of several such swarms, of considerable magnitude compared with the swarm which Mr. Lynn suggests gives rise to the average length of sunspot periods. There are not only considerable differences in the length of successive sunspot periods, but the height of successive waves of the sunspot curve varies, and the form of the wave changes, groups of three or four similar waves or loops of the sunspot curve occurring successively. Such irregularities seem to me to point to complicated changes taking place within the sun, rather than to a combination of regular perturbations from without. Perhaps we shall some day get an inkling of the meaning of such irregularities, but I fear that we are very far at present from understanding what a sunspot is.—A. C. Ranyard.]

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CELLULOSE AND SOME OF ITS MORE RECENT APPLICATIONS.

By Chas. A. Silberrad, B.A., B.Sc.

THOUGH cellulose is an invariable constituent of plants, of whose cell-walls it forms the supporting frame-work, it is rarely found pure, as, except in the cellular tissue of the youngest shoots, it always contains more or less ash. Still, cotton-wool and Swedish filter-paper consist of the approximately pure substance, especially the latter after treatment with hydrofluoric acid, whereby all mineral matter is extracted.

However, the preparation of pure cellulose from any material containing it—*e.g.*, cotton-wool—is not a matter of great difficulty, it being only necessary to digest it alternately with bromine water and a dilute alkaline solution until the bromine water is no longer decolorized. The fibre is then boiled in dilute alkali and washed in turn in dilute acid, alcohol and ether, and finally dried.

Thus prepared, it contains a certain amount of hygroscopic moisture, amounting to from seven to nine per cent. of its weight; when this is removed, the simplest composition deducible from analysis is $C_6H_{10}O_5$, but it seems clear from its properties that its molecular weight must be many times that represented by the foregoing formula.

Solvents of Cellulose.—Cellulose is insoluble in all ordinary solvents, but is dissolved by certain reagents, of which the two following are the most important: (*a*) Schweitzer's reagent, which consists of an ammoniacal solution of cupric hydrate. From solution in this liquid the cellulose may be reprecipitated on addition of acids, alcohol, salt, or various other substances, in a gelatinous state, drying to a material closely resembling gum arabic in appearance. (*b*) A solution of zinc chloride in twice its weight of hydrochloric acid. This solvent behaves very similarly to the first mentioned, except that the cellulose is reprecipitated on dilution. Such solution and reprecipitation afford a ready means of purification.

The solvent power of the first named of the above liquids is the basis of the manufacture of the so-called *paper boards*. For this purpose sheets of unglazed paper are left in contact with the ammonio-cupric solution for a short time—just long enough for the fibres to be superficially attacked. The requisite number of these sheets are then placed one on top of the other, passed between rollers and dried; by this process they become united together into a board-like material, impervious to water, which property is retained at 100° Cent.

Action of Nitric Acid.—If cellulose, *e.g.*, blotting-paper, be simply immersed in ordinary strong nitric acid (specific gravity 1·42) it undergoes a curious transformation. Its composition is unchanged, but the strength of the paper is increased tenfold, while at the same time its linear dimensions are diminished ten per cent.

The action of stronger nitric acid and of mixtures of nitric and sulphuric acid in the production of gun-cotton and the various pyroxylines, as well as the preparation of collodion by dissolving the last named in a mixture of alcohol and ether, are too well known to need any further account here; but the peculiar properties of a mixture of camphor and pyroxyline may be worth noting, as it is of these two substances that *celluloid* consists.

Celluloid was first prepared by Hyatt, of Newark, U.S.A. It may be obtained either by direct addition of pyroxyline to melted camphor, or by strongly compressing the two together, or lastly by dissolving the two in some common solvent, as ether-alcohol.

The method usually adopted on the manufacturing scale is a combination of the second and third above mentioned. The pyroxyline is prepared by treating unsized paper with moderately strong nitric and sulphuric acids, whereby a product is obtained consisting of a mixture of the tetra- and penta-nitrates of cellulose.

The camphor is dissolved in the minimum quantity of alcohol, and this solution sprinkled upon the dry sheets of pyroxyline in such quantity that there is one part of camphor to two of pyroxyline. On the sheet so treated another is placed, and the same process repeated, and so on till a sufficient thickness is obtained.

There is thus produced a translucent mass which is worked between rollers, first in the cold and then at a higher temperature; it is next subjected to hydraulic pressure at a temperature of about 60° Cent., for twenty-four hours, and finally cut into sheets of the desired thickness and dried for several days at a moderate heat. The substance so obtained appears quite homogeneous, and may be cut and turned in the cold or moulded under pressure at a higher temperature.

It is very readily coloured by pigments or dyes, which may be either mechanically mixed in a state of powder or dissolved with the camphor in the alcohol.

Artificial tortoiseshell is produced on the same principle as damascene steel, *i.e.*, by welding together alternate plates of differently tinted celluloids.

As might be anticipated from its composition, it is extremely inflammable, but has been shown to be non-explosive under all conditions.

Action of Sulphuric Acid.—Vegetable Parchment or Parchment Paper.—If cellulose, *e.g.*, blotting-paper, be rapidly passed through moderately strong sulphuric acid (specific gravity 1·5—1·6), and then well washed in water, it acquires properties very similar to those of parchment. The resulting preparation is now extensively used under the names of vegetable parchment or parchment paper.

This change is due to the conversion of the cellulose on the surfaces of the paper into a peculiar modification known as amyloid, which may be precipitated pure in a gelatinous form by diluting a solution of cellulose in concentrated sulphuric acid.

If cellulose be left in contact with acid of specific gravity 1·5 for some time, it becomes friable, forming a substance called *hydro-cellulose*, which is soluble in alkalies. By means of this reaction the cotton may be separated from the wool in a mixed fabric, as the latter is unacted upon.

Action of Alkalies.—Mercerization.—If cotton cellulose be treated with a concentrated solution of soda or potash and then washed, it is found to have undergone a remarkable change in properties. From the name of its discoverer (Mercer) this change is termed *mercerization*.

The way in which Mercer was led to his discoveries is interesting as showing how one result may lead to another wholly unconnected with it. He was making a series of experiments to determine whether any alteration occurred in the composition of a solution on filtering it, and in the course of these he passed a strong solution of caustic soda through several layers of cotton-cloth. He certainly found a considerable change in the composition of the solution on filtering, but was able to fully account for it by what turned out to be the far more important change produced in that of the cotton-cloth, for this proved to be approximately expressed by the formula $C_6H_{10}O_5$ NaOH; and though, on washing, all the soda was removed, the properties of the fibre were found to have undergone a marked change. Their length was contracted to the extent of twenty per cent., while at the same time there was an increase of thirty to thirty-five per cent. in strength. A still more important alteration was the increased affinity

for such dye-stuffs as will dye cotton without a mordant, *e.g.*, the diphenyl derivatives—Congo red and the benzidine dyes.

Cellulose Thiocarbonate.—Certain theoretical views led Messrs. Cross and Bevan to an examination of the action of carbon bisulphide on the mercerized cotton, with results which will probably have most important practical applications in the near future, and which have already formed the subject of at least one patent.

If the above-mentioned compound of cellulose and soda be exposed to the action of the vapour of carbon bisulphide, it is gradually converted into a yellowish mass which, when placed in water, swells up, and finally dissolves to form a solution of *Cellulose thiocarbonate*.

This same solution may be more readily produced by bringing together two parts of cellulose, one of caustic soda, two of carbon bisulphide, and eight of water.

From this solution the thiocarbonate may be precipitated in a pure state by addition of alcohol or strong brine, after which it may be redissolved in pure water to form a colourless solution of great viscosity. Thus, a four per cent. solution is as thick as treacle, while a bottle filled with one containing eleven per cent. of the thiocarbonate may be inverted for a considerable time without any risk of loss. But its most important property is its power of coagulation, which occurs spontaneously on standing for a considerable period, or immediately on heating above 60°, or by addition of an acid. This coagulation is due to the cellulose separating out in the pure state, forming a gelatinous mass which gradually shrinks, but in such a manner as to form *an exact miniature of the interior shape of the containing vessel;* all the sulphur and alkali are found in the liquid which separates from the shrunken mass. The cellulose thus reproduced varies in consistency according to the concentration of the original solution, but is always perfectly homogeneous; thus, it may be obtained in a form closely resembling the softer varieties of india-rubber, or in one practically indistinguishable from horn, and it is not merely in appearance that this latter resembles horn but also in its consistency, for it is hard and tough and perfectly adapted for turning. Finally, it is found to possess the same increased affinity for dye-stuffs that is exhibited by the original "mercerized" cotton.

The importance of the discovery is manifest, especially in view of the inevitably failing supplies of ivory, which have already resulted in the success of the ebonite and celluloid manufactures, over which it is clear that this preparation possesses many and great advantages; for none of the materials required in its production are expensive, and it is free both from the brittleness of ebonite and the inflammability of celluloid, while the readiness with which it can be obtained in any desired shape gives it a still more marked superiority over either of these products.

SYMPATHETIC EXPLOSIONS.

By C. A. Mitchell, B.A. Oxon.

In an explosion we have the sudden evolution of large quantities of gas which meet with external resistance. Thus, in the case of dynamite, the substance is suddenly decomposed into gases, which meet with the resistance offered by the surface of the earth on the one side and with that opposed by the weight of the atmosphere on the other.

Explosive agents are roughly classified as "high" and "low" explosives, the former term being usually applied to those exploded by detonators and used as destructive agents rather than for the propulsion of projectiles. Nitro-glycerine and gunpowder may be taken as representatives of the two classes.

Substances liable to explosion are, as it were, in a state of *unstable equilibrium*, and often a slight cause is sufficient to so disturb that equilibrium that a fresh arrangement of the particles takes place—in other words, an explosion. A somewhat analogous instance of instability is to be noticed in the case of water cooled slowly below its freezing-point without solidifying, as occasionally happens in bedroom jugs. When the jug is lifted the movement destroys the equilibrium and the water suddenly becomes ice. *Prince Rupert's drops* illustrate the same phenomenon. These are small pear-shaped globules prepared by allowing molten glass to fall from a short distance into cold water, which causes the exterior to cool more rapidly than the interior, and the mass is left in such a state of tension that, if the extreme tip of the drop be broken off with pliers, the whole flies to powder.

Explosive bodies differ very considerably in stability. The so-called iodide of nitrogen, a black powder formed by digesting iodine in a solution of ammonia, explodes when dry with the slightest touch. Nitro-glycerine is more stable and requires the blow of a hammer for its explosion. This substance is prepared by allowing strong nitric and sulphuric acids to act upon glycerine, care being taken to keep the temperature low. It is an oily liquid and is very poisonous. As an explosive it is uncertain and has been the cause of many accidents. When mixed, however, with an inert substance, such as sawdust, it is much more stable. This is the principle made use of in the manufacture of *dynamite*, which consists of nitro-glycerine absorbed by a porous siliceous earth called *kieselguhr*.

Dynamite is very stable under ordinary conditions, as was well shown in the experiments carried out in the Lauenburg Fabrik in 1876.* A barrel containing five hundred and forty kilograms† was dropped a distance of twenty feet on to a paved road, and in a second experiment a weight of ten kilograms was dropped on to a dynamite cartridge. In neither instance was there any explosion. The dynamite used burned quietly when thrown on a fire, but exploded powerfully even on an open surface when a detonating cartridge was exploded in contact with it. We have thus the curious phenomenon of a substance which burns quietly and withstands a heavy blow, but which disintegrates readily when another less stable body is exploded beside it. This is explained by the theory of an explosive wave which is communicated from the one explosive to the other. Where an explosive burns quietly there is much slower decomposition, and the particles first taking fire radiate their heat too quickly for the entire mass to be simultaneously raised to the temperature of explosion. If the heat cannot be dissipated sufficiently fast, as in the case of confined gun-cotton, an explosion follows just as when a detonator is used. Thus the unstable equilibrium may be disturbed either by heat or by communication of a mechanical vibration. This latter method of *sympathetic explosion*, as it has been termed, is now very generally used to effect explosion of charges of dynamite and gun-cotton.

That the deflagration of one substance can produce a sympathetic explosion at a distance has been illustrated by many accidents. The explosion of a quantity of nitro-glycerine in one shed has often caused the explosion of other materials some distance away. A remarkable instance occurred in 1888, in a factory at Wandsworth,

* *Ber. Deut. Chem. Ges.*, IX., 1802. † A kilogram = 2·2 lbs.

where the caps for toy pistols were made. It was believed that the explosion was owing to one of these *amorces*, containing more than the regulation amount of composition, having been cut with scissors, and thus causing all the rest to explode. The shed was wrecked, and three girls lost their lives. A similar case happened in France, where a child was killed by cutting open a cap, which caused two large packets to explode.

When an explosion is communicated from one cartridge to another there is a gradually weakening effect. This was proved experimentally, in 1872, by Captain Müntz, at Versailles. The explosion of the first charge excavated a funnel-shaped hole in the ground measuring ·9 metre* in diameter. The shock caused a second similar cartridge placed at some distance to explode, but in this case the diameter of the hole excavated was only ·66 metre.

Captain Colville found that there was a definite relation between the weight of the charge used and the distance between the cartridges. A charge weighing one kilogram, and containing seventy-five per cent. of dynamite, communicated its explosion on hard ground ·3 metre. Where D represents the distance in metres, and C the weight of the charge in kilograms, he showed that under these conditions $D = 3\ C$. When the cartridges were laid on a rail, the distance to which the explosion could be communicated was increased, and $D = 7\ C$. On the other hand, on soft or ploughed earth the distances were much less.

To explain this property of explosives, Sir Frederick Abel advanced the attractive theory of a sympathetic rhythmic vibration between the substance detonating and that detonated, analogous to the synchronous vibrations set up by sound waves. A certain note of a piano will often cause a glass to jingle, and if the glass be made to emit its note it will be found to be the same as the note of the piano—that is, each vibrates at the same rate. Sir Frederick Abel thus expresses his theory: "Vibrations produced by particular explosions, if synchronous with those which would result from the explosion of a neighbouring substance, will, by their tendency to develop those vibrations, either determine the explosion of that substance or at any rate greatly aid the disturbing effect of mechanical force suddenly applied."

Facts in support of this are that sometimes a feeble detonation will determine an explosion when a more violent one will not. Thus iodide of nitrogen will not cause compressed gun-cotton to explode, nor does nitro-glycerine cause the explosion of gun-cotton in sheets on which is placed the case of nitro-glycerine.

The interesting experiments of Champion and Pellet† tend, perhaps, to confirm this.

1. A very small quantity of iodide of nitrogen, detonated at one end of a long narrow tube, caused the explosion of a similar quantity of the same substance placed at the other end of the tube at a distance of seven metres. That the transmitted concussion was slight was shown by the insertion of a light pith ball in the middle of the tube.

2. Damp iodide of nitrogen was fixed to the strings of a bass viol. When it was dry the strings of a similar instrument were made to vibrate at a distance. A detonation occurred only when a note giving sixty vibrations per second was sounded. The G cord caused an explosion, while the E cord did not. The vibrations produced by metal plates acted in the same manner as strings.

From these results the observers came to the conclusion that explosion was due to vibratory motion independent of heat and shock.

This theory has not met with general acceptance. Eissler‡ is strongly opposed to it. He urges that all the experiments of Champion and Pellet may be explained by taking into account the vibrations of the supports and the resulting friction. Moreover, the characteristic feature of a given note has never been established, but only the fact that below a certain rate of vibration the explosive effect ceases. He explains the facts by the supposition of two orders of waves, one explosive and the other purely mechanical.

In substantial agreement with him, Berthelot§ also objects to the theory of sympathetic vibrations. He proves that the chemical stability of matter is unaltered by merely sonorous vibrations, even when the substances experimented on are as unstable as ozone, which is so readily changed into oxygen. Therefore, according to him, sonorous waves cannot be the real agents in chemical decomposition and explosion. His explanation is that "explosive matter detonates, not because it transmits the vibratory energy by vibrating in unison, but, on the contrary, because it stops it and appropriates the energy." With reference to Abel's experiments, he argues that if gun-cotton can explode nitro-glycerine, why cannot nitro-glycerine explode gun-cotton, assuming that the two compounds vibrate in sympathy; whereas this transformation of energy into work may be readily explained by a difference in constitution.

The same chemist made a large number of experiments to determine the velocity of the explosive wave in the case of different explosives.‖ Long, narrow tubes, made of lead, tin, or Britannia metal were used, and the rate of propagation of disturbance through the tube measured. He found this to depend on—(1) The diameter of the tube; (2) the density of the explosive; (3) the resistance of the material of the tube. The explosive wave from compressed gun-cotton had a mean velocity of five thousand two hundred metres per second in lead tubes, and of six thousand metres per second in tin tubes. Liquid nitro-glycerine gave results varying from one thousand and seventy-eight to one thousand three hundred and eighty-six metres per second; while dynamite had a mean rate of two thousand five hundred and forty-three metres per second. It was found a matter of great difficulty to detonate the nitro-glycerine in such narrow tubes. A curious feature was, that whether the tubes were curved or straight, the results obtained were substantially the same.

* A mètre = 39·3 inches. † *Comptes rendus*, LXXV.

‡ *Modern High Explosives.* § *Les Matières Explosives.*
‖ *Comptes rendus*, 100, 314—320.

GLOBULAR STAR CLUSTERS.

By J. E. Gore, F.R.A.S.

THE term "globular cluster" has been applied to those clusters of stars which evidently occupy a space of more or less spherical form. Some of these "balls of stars," as they have been called, are truly wonderful, and are among the most interesting objects visible in the stellar heavens. Good specimens of the class are, however, rather rare objects, and there are not many in the northern hemisphere. The most remarkable is that called "the Hercules cluster," but known to astronomers as 13 Messier, it being No. 13 in the first catalogue of remarkable "nebulæ" formed by Messier, the famous discoverer of comets. It was discovered by Halley in 1714. Messier was certain that it contained no stars! This wonderful object lies between the stars Zeta and Eta Herculis, nearer to the latter star. It may be seen with a binocular or good opera-glass as a hazy

star of about the sixth magnitude. When examined with a good telescope it is at once resolved into a multitude of small stars, which can be individually seen, and even counted with large telescopes. The number of stars included in the cluster was estimated at fourteen thousand by Sir William Herschel, but the real number is probably much smaller. Were the number so great as Herschel supposed, I find that the cluster would form a much brighter object. It has been well photographed at the Paris and Lick Observatories and by Dr. Roberts.* Its globular shape is evident at a glance, and we cannot doubt that the stars comprising it form a gigantic system, probably isolated in space.

Most people might think that this cluster was a mass of double and multiple stars, but this is not so; the components, close as they are, are too far apart to be considered as true double stars. Mr. Burnham, the famous double star observer, finds *one* close double star near the centre, and notes the remarkable absence of close double stars in bright and apparently compressed clusters.

In the same constellation, Hercules, between the stars Eta and Iota, but nearer the latter, will be found another object of the globular class, but not so bright, or so easily resolvable into stars as the cluster described above. It is known as 92 Messier. Buffham, examining it with a nine-inch mirror, thought the component stars brighter but more compressed than in 13 Messier. This object was photographed by Dr. Roberts, in May, 1891, with a twenty-inch reflecting telescope, and an exposure of one hour. Dr. Roberts says: "The photograph shows the cluster to be involved in dense nebulosity, which on the negative almost prevents the stars being seen through it, and on the print quite obscures the stars. The stars in this, as in all other globular clusters, are arranged in various patterns, and many of them appear to be nebulous."

Another fine globular cluster is that known as 5 Messier. It lies closely north of the fifth magnitude star 5 Serpentis. It was discovered by Kirch in 1702, and was observed in 1764 by Messier, who found he could see it with a telescope of one foot in length, but could not resolve it into stars. Sir William Herschel, with his forty-foot telescope, could count about two hundred stars, but could not distinguish the stars near the central blaze. Sir John Herschel describes it as an excessively compressed cluster of a globular form, with stars of the eleventh to the fifteenth magnitude condensed into a blaze at the centre. Lord Rosse found it more than seven or eight minutes of arc in diameter, with a nebulous appearance in the centre. This cluster was photographed by Dr. Roberts with a twenty-inch reflector, in April, 1892. The photograph shows the stars to about the fifteenth magnitude, and "the cluster is involved in dense nebulosity about the centre. The nebulosity hides the stars even on the negative."

Another fine object of this class is that known as 15 Messier, in Pegasus, discovered by Maraldi in 1745. Sir John Herschel describes it as a remarkable globular cluster, very bright and large, and blazing in the centre. Webb found it a glorious object with a nine and one-third inch mirror. It was photographed by Dr. Roberts in November, 1890, with an exposure of two hours. He says: "The photograph confirms the general descriptions, and the negative shows, separately, the stars of which the cluster is composed distinctly through the nebulosity to the centre. Many of the stars have a nebulous appearance, and they are arranged in curves, lines and patterns of various forms, with lanes or spaces between them."

The cluster known as 3 Messier, in Canes Venatici, is another fine object of the globular class. Sir John Herschel described it as a remarkable object, exceedingly bright and very large, with stars of the eleventh magnitude. Admiral Smyth thought that it contained at least a thousand stars. Buffham found it resolved even in the centre with a nine-inch mirror. It was photographed by Dr. Roberts in May, 1891, with an exposure of two hours, and the photograph confirms the general descriptions given of the cluster, though "the print fails to show the stars that on the negative crowd the space covered by the dense nebulosity." Dr. Roberts remarks that "nebulosity seems invariably to be present in globular clusters."

We may also mention the globular cluster known as 2 Messier, situated a little north of the star Beta Aquarii. It was discovered by Maraldi in 1746. Sir John Herschel compared it to a mass of luminous sand, and estimated the stars to be of the fifteenth magnitude. Sir William Herschel, with his forty-foot telescope could "actually see and distinguish the stars even in the central mass." I estimate that this cluster contains about four thousand stars, or more than the number of stars visible to the naked eye at one time.

In the southern hemisphere there are some magnificent examples of globular clusters, and, indeed, this hemisphere seems to be richer in these objects than the northern sky. Among these southern clusters is the truly marvellous object known as Omega Centauri. Its apparent size is very large—about two-thirds of the moon's diameter—and it is distinctly visible to the naked eye as a hazy star of the fourth magnitude, and I have often so seen it in the Punjab sky. Sir John Herschel, observing it with a large telescope at the Cape of Good Hope, describes it as "beyond all comparison the richest and largest object of its kind in the heavens. . . . All clearly resolved into stars of two sizes, viz., thirteen and fifteen . . . the larger lying in lines and ridges over the smaller; . . . the larger form rings like lace-work on it." This wonderful object has recently been photographed by Dr. Gill at the Royal Observatory, Cape of Good Hope,† and also at Arequipa, Peru, with a telescope of thirteen inches aperture. On the latter photograph the individual stars can be distinctly seen and counted. The enumeration has been undertaken by Mr. and Mrs. Baily, and a mean of their counts gives six thousand three hundred and eighty-nine for the number of stars in the cluster; but they consider that the real number is considerably greater.

Another wonderful object is that known as 47 Toucani, which lies near the smaller magellanic cloud. Sir John Herschel describes it as "a most magnificent globular cluster. It fills the field with its outskirts, but within its more compressed part I can insulate a tolerably defined circular space of 90″ diameter, wherein the compression is much more decided, and the stars seem to run together, and this part has, I think, a pale pinkish or rose colour . . . which contrasts, evidently, with the white light of the rest. The stars are equal, fourteen magnitude, immensely numerous and compressed . . . Condensation in three distinct stages . . . A stupendous object."

There are a number of other globular clusters of smaller size in the southern hemisphere, but the above are the most remarkable.

The actual dimensions of these globular clusters is an interesting question. Are they composed of stars comparable in size and mass with our sun? or are the component stars really small and comparatively close together? This is a difficult question to answer, as the

* See Knowledge for May and June, 1893.

† See photograph of this Cluster taken at the Cape Observatory, published in Knowledge for June, 1893.

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distance of these objects from the earth has not yet been determined. They may, on the one hand, be collections of suns similar in size to ours and situated at vast distances from the earth; or, on the other hand, the stars composing them may be comparatively small objects, lying at a distance from the earth not exceeding that of some stars visible to the naked eye. Perhaps the latter hypothesis may be considered the more probable of the two; but there is really no reason to suppose that these collections of suns are comparatively near our system. The probability seems to be in favour of their great distance from the earth, for in all these clusters the component stars are very faint. The question of the absolute size of the component stars is one which has not hitherto been sufficiently considered. Let us examine both alternatives, and let us take the cluster Omega Centauri, as one in which the number of the component stars has been *actually counted*. Assuming that the real number of stars included in this cluster is ten thousand, and that they are individually equal, on an average, to our sun in mass and volume, we may estimate the distance and dimensions of the cluster. Taking the stellar magnitudes of Omega Centauri as four (as estimated at Cordoba Observatory), I find that with the number ten thousand the average magnitude of the component stars would be fourteen. This agrees with Sir John Herschel's estimate of thirteenth to fifteenth magnitude. Now to reduce the sun to a star of the fourteenth magnitude, I find that—assuming the sun to be twenty-six and a half magnitudes brighter than an average star of the first magnitude, as shown by photometric measures—it would be necessary to remove it to a distance equal to seventy-nine million four hundred and forty thousand times the earth's distance from the sun—a distance so great that light would take no less than one thousand two hundred and fifty-three years to reach us from the cluster! Taking the apparent diameter of the cluster at twenty minutes of arc, I find that its real diameter, if placed at the above distance, would be four hundred and sixty-one thousand five hundred and forty times the sun's distance from the earth—a diameter so great that light would take over seven years to cross it! Supposing the ten thousand stars which compose the cluster to be equally distributed through this sphere, I find that the distance between the individual stars would be about twenty-one thousand times the sun's distance from the earth, or about four months' journey for light. This is, of course, an enormous distance—about seven hundred times the distance of Neptune from the sun; but still the distance of the nearest fixed star from the earth—Alpha Centauri—is over twelve times greater; and considering the vast extent of the visible universe, not to speak of infinite space, there is nothing to militate against the existence of a cluster of suns with the components separated from each other by the great distance just found.

The distance found above for Omega Centauri is certainly enormous, and might lead us to suspect that these globular clusters are external universes. Judging, however, from the average distance recently found for stars of the first and second magnitudes, the distance of ordinary stars of the fourteenth magnitude—on the supposition that they are of the same size and brightness, and that their light is simply reduced by distance—would be about ten times greater than that found above for Omega Centauri. If, then, we increase the distance of the cluster ten times, it will be necessary to also increase the diameter of the component stars to ten times that of the sun. This would give them a volume a thousand times greater than that of our sun—a result which is, of course, highly improbable.

If, on the other hand, we do not like to admit that each of the faint points of light composing the cluster is equal in volume to our sun, let us diminish the distance ten times. If we do so we must also diminish the diameters of the component stars ten times. This would make them about the size of the planet Jupiter, and it seems very improbable that such comparatively small bodies could retain their solar heat for any length of time They would probably have cooled down, as Jupiter has done—at least to a great extent—ages ago, and would not now be visible as a stellar cluster. Even this reduction of the distance to one-tenth of the value found above would still leave the cluster at an immense distance from the earth, a distance represented by one hundred and twenty-five years of light travel. A reduction of the distance to one-tenth of this again, or twelve and a half years of light travel, would make the components about the size of the earth, and that bodies of this small size could shine with stellar light seems to be an untenable hypothesis.

There is, however, another point to be considered with reference to the size of the bodies composing a globular cluster. This is the character of their light. I am not aware that the spectrum of a globular cluster has yet been thoroughly examined, but if that of Omega Centauri gives a spectrum of the first or Sirian type, it would modify the above conclusions to some extent. It now seems probable that stars having a spectrum of the Sirian type are intrinsically brighter than the sun. I have shown in a former paper that Sirius is about forty times brighter than our sun would be if placed at the same distance, although the mass of Sirius is but little more than twice the sun's mass. The components of a star cluster, therefore—if of the Sirian type of stars—might be as bright as the sun, and at the same time have a smaller mass and volume.

These considerations seem to me to warrant the conclusion that these globular clusters are probably composed of stars of average size and mass, and that the faintness of the component stars is simply due to their immense distance from the earth.

[Mr. Gore's suggestions for determining the distance of stellar clusters will be followed with interest by readers of Knowledge; but his conclusions, I venture to think, are doubtful, as they are founded upon an assumption which, it seems to me, we are not warranted in making—viz., that it is "an untenable hypothesis" that stars of the size of Jupiter or the earth could shine with stellar light, because they must have cooled so that they would now be dark stars, and consequently invisible to us.

Mr. Gore might possibly be warranted in coming to such a conclusion if he knew (1) that all parts of the stellar universe commenced to cool down at the same period; (2) that the cooling went on everywhere uniformly; and (3) that there were never any collisions between stars giving rise to the reheating of cooled masses.

Such collisions seem much more probable between the stellar members of a close cluster than between isolated stars. In fact, if the stars of the stellar cluster are moving under the influence of their mutual gravity, it seems impossible to conceive of a system of motion in which collisions would not occasionally occur, and the more compact the cluster the more frequently would such collisions happen, giving rise to a rekindling of the stellar brightness by the conversion of energy of translation into heat.

Mr. Gore seems to think that it is "highly improbable" that any star could have a volume a thousand times greater than that of our sun, while, on the other hand, he thinks it "an untenable hypothesis" that any bright star could have a diameter as small as that of Jupiter, or about a tenth of the solar diameter. But in the case of the

Pleiades cluster we have a range of apparent brightness which corresponds to at least twelve and a half magnitudes, that is, the brighter stars of the cluster give one hundred thousand times as much light as the smaller stars which, it will hardly be doubted, are at the same distance from us as the large stars of the cluster, and in the case of the cluster about α Crucis there is probably a range of at least fifteen magnitudes, which corresponds to a light ratio of one to a million.

If we adopt Mr. Gore's theory with regard to the great distance and size of these star clusters, we are carried back to the old theory, that clusters and nebulæ are distant galaxies, outside and unconnected with the Milky Way system; an assumption which has very generally been rejected since the publication of Herbert Spencer's paper on the "Nebular Hypothesis" in the *Westminster Review* for July, 1858, in which he showed that the general distribution of nebulæ and clusters corresponded with and was complementary to the general distribution of luminous stars, proving that the nebulæ and clusters were members of the galactic system—a fact which was brought out still more clearly in 1869 by Mr. Proctor's papers and charts illustrating the distribution of nebulæ and clusters, and which is now still further enforced by the beautiful charts of Mr. Sydney Waters, published in the last number of the *Monthly Notices*.

Assuming, then, that the star clusters are at the same distance from us as the Milky Way and the large stars associated with it, we must either believe that the first magnitude stars connected with the Milky Way are millions of times larger than our sun or that the small stars of the clusters are much smaller than the sun, and in some cases probably smaller than the earth, if they compare in brightness with our sun.—A. C. Ranyard.]

ON THE INHABITANTS OF SOME COMMON GALLS.

By the Rev. Alex. S. Wilson, M.A., B.Sc.

On certain plants swellings, excrescences, and deformities of various kinds occur, caused by the action of insects. The oak-galls imported in quantities from the Levant, and largely used in the manufacture of ink, are of this nature. Gall-making insects show a marked preference for the oak, but some species select the willow, poplar, and other trees, while others confine themselves to various species of shrubby or herbaceous plants. The study of galls opens up a singularly interesting chapter of natural history. To the entomologist they offer an inviting field for original research; for the botanist they have at least a pathological significance; some knowledge of them is of practical use to farmer and gardener; while the attractive appearance of some kinds is fitted to excite the curiosity of every observant lover of Nature.

Besides the insect which makes it, a gall is often tenanted by other species, termed inquilines, from the Latin *inquilinus*, meaning a lodger. Of this fact the writer had evidence afforded lately by finding on the common germander speedwell a gall, which, when opened, was found to contain four orange-coloured larvæ, along with three white ones which apparently belonged to another species altogether. The cuckoo's egg in the hedge-sparrow's nest at once rose before the mind, and it was difficult to resist the conclusion that we had before us evidence of a similar habit on the part of insects. To place the matter beyond doubt, it would have been necessary to rear the perfect insects from the gall. Unfortunately, an attempt to do so proved unsuccessful. On a former occasion, from an abnormally thickened twig of the pine which was placed under a glass shade we obtained after some days a whole swarm of midges. Some such method is followed when it is desired to rear the insects from the galls; the shoot or leaf which bears the galls is placed in water and covered with muslin, or, better, in a wide-mouthed bottle, having damp sand in the bottom. For this purpose the more advanced galls must be selected. It is a common experience in experiments of this kind that instead of a single species different kinds of fly emerge from the same gall, and it is not always easy to determine which is the original gall-maker. In this way it has been ascertained that the galls of the Cynipidæ are often inhabited by other species of Cynips, of Synergus, Amblynotus, and Synophrus. On one of the willows a gall which resembles a pine-cone grows; it is made by a large species of Cecidomyia, which inhabits the centre, and in the outer part numerous smaller species of Cecidomyia take up their abode. Certain saw-flies are inquilinous in the galls of the gall-gnats, and certain of the latter return the compliment. In many cases the inquiline causes the death of the original inhabitant, but in other instances a *modus vivendi* seems to be arranged, landlord and lodger contriving to exist together in harmony, sharing the substance of the gall for food. Certain kinds of beetle have also been found in galls, for whose presence it is not easy to account, seeing they are not gall-feeders. Both the gall-maker and its guests are liable to the attacks of parasitic insects, especially of ichneumon flies; these deposit their eggs in the larvæ within the gall. For this reason it often happens that from a gall one may fail to obtain any perfect insects except the parasitic species. Other hymenopterous parasites are the Proctotrypidæ and Chalcidæ; the larva of one of the latter preys on the larvæ of *Cynips glutinosa*, and its lodger, *Synergus faciatus*. It is otherwise with the Braconidæ and Ichneumonidæ occurring in the oak-apple; these are believed to be parasitic, not on the owner of the gall, but on the inquilinous Tortricidæ.

As the guests may belong to different species, and as not only the gall-maker but each of the lodgers may have their own specific parasites, we may have an extraordinary variety of insects inhabiting the same gall. From one of the willow-galls Mr. B. Walsh obtained sixteen different insects, preyed upon by eight others, twenty-four in all, representing eight orders—quite a respectable entomological collection.

The treasures of the hive are liable to be appropriated in a similar way by intruders, such as the fly Volucella, which effects an entrance more easily on account of its deceptive resemblance to a bee, but the honey gatherers would seem to have much less cause for complaint on this score than have the makers of the galls.

Dr. Adler arranges the inhabitants of galls under three heads—gall-makers, inquilines, guest flies or cuckoo flies and parasites. He also mentions commensals, under which may be included those beetles, already referred to, which do not feed on the galls, and also the larvæ of certain moths which Mr. P. Cameron describes as attaching themselves to the exterior of galls and feeding on them, but without interfering with the occupants. The larvæ of the inquiline usually develop more rapidly than do those of the gall-maker, and a saving of time may be one of the advantages which the inquilinous habit secures. Such at least appears to be the advantage in the case of the cuckoo; for the remarkable instinct of this bird, there can be little doubt, has reference to the shortness of its stay in this country. The young cuckoo, a few days after it is hatched, is said to eject the young hedge-sparrows from the nest, and

thereafter enjoys the exclusive attention of its foster parents. Did the cuckoo require to build a nest and rear its young in the ordinary way, it is doubtful whether the latter would be sufficiently advanced to take their departure along with the other birds when the time for leaving our shores arrived.

The most perfect galls are made by the Hymenoptera, though those of the Diptera are perhaps more numerous. The Hemiptera, Lepidoptera, Coleoptera, and several other orders include gall-making species. A species of beetle or gall-weevil forms pseudo-galls on the willow; the leaves of the lime, poplar, elm and many other plants are galled by plant lice; the curiously shaped Chinese galls are also formed by one of the aphides (*Aphis Chinensis*). These grow on a species of Rhus and are of commercial importance on account of the high percentage of tannin they contain. Coccus galls on the Australian Eucalypti constitute what is known as vegetable coral; the male insect, as Mr. Froggat tells us in his recent paper, occupies a separate gall from the female. The larvæ of Lepidoptera are more frequently leaf-miners and leaf-rollers than gall-makers, but several moths have been reported as bearing this character; one forms a fusiform gall on a creeping plant in New Zealand; a lepidopterous gall from Patagonia has also been described by Mr. Cameron which closely resembles the oak marble gall of *Cynips kollari*. Mite-galls in the form of little tufts of hair, or thickened and blistered leaves, due to species of Phytopus, are of very frequent occurrence. Mites are not properly insects, but belong to the Arachnida; galls of theirs may be seen on the stitchwort, on the meadow grass and several others. Examples of "worm-galls" occur on some of the hawkweeds and on species of Plantago. Although mite and aphis galls are of common occurrence, they are not so perfect nor are their forms so characteristic as those made by Hymenoptera and Diptera; they are generally more or less open. This is also the case with many dipterous galls; those of the Hymenoptera, on the other hand, are completely closed.

Two families of insects stand out pre-eminently as gall-makers—the Cynipidæ among the Hymenoptera, and the Cecidomyidæ, a family of Diptera; the former, alongside of which we may place the allied Tenthredinidæ, or saw-flies, are the gall-wasps or true gall-flies, as distinguished from the Cecidomyias, which are the gall-midges or gall-gnats. The females in both groups are provided with a slender ovipositor; with this the punctures are made in vegetable tissues and the eggs introduced. How the presence of these should stimulate the tissues into abnormal growth is a question which has attracted a considerable amount of attention, and can hardly be said to be finally settled yet. It was formerly supposed that along with the egg the insect also injected some secretion into the wound, which acted as an irritant. This view gained plausibility from the ovipositor being merely a modification of the wasp's sting. Latterly, however, the irritant properties of the secretion have been questioned; it has been shown in many cases that the formation of the gall does not commence until after the larvæ are hatched, and Dr. Adler holds that the formation of galls must be attributed almost entirely to the action of the larvæ in feeding, aided possibly by their salivary secretions. That this is the true explanation of the formation of a large number of galls admits of no doubt; but if Prof. Trail's assertion that the galls of Cynips and Tenthredo are fully formed before the eggs they contain are hatched be true, then their formation must be due to some other cause than the activity of the larvæ.

Not only do different gall-makers select different plants, but they very often confine themselves to particular parts of the plant, such as the leaf, young shoots, stems, floral organs, or roots. The galls of the oak, which are exceedingly numerous, are mainly the work of Cynipidæ. *C. kollari* produces the marble galls often used to ornament rustic work; the oak-apple or sponge is caused by *Andricus terminalis*; the currant gall by *Spathegaster baccarum*; *Neuroterus lenticularis* gives rise to the button galls or oak spangles on the under sides of the leaves; the catkins are galled by *Andricus occultus*; *Dryophanta scutellaris* makes the succulent cherry-galls; and the large galls on the root of the oak are occasioned by *Aphilothrix radicis*.

The species of gall-fly are very numerous, and as each gall-maker follows its own pattern, their galls assume a great variety of shapes, as their common names indicate. But the same thing has happened here as was formerly found to be the case with parasitic leaf fungi; in a number of instances, two forms, which were at first described as distinct species, turn out to be only different phases in the life-cycle of one and the same species; and as the alternating generations produce totally different galls, we have the latter exhibiting the phenomenon of dimorphism. The currant-galls of the oak, which appear in spring, and the oak spangles, which are formed towards the end of summer, are believed to be related in this way. The brood which emerges from the former consists of both males and females; the autumnal galls yield nothing but females. Among twelve thousand specimens reared from the Devonshire gall, Mr. F. Smith found not a single male; and different observers relate a similar experience with other galls. There can be no doubt, therefore, that the gall-flies resemble the aphides in their power of multiplying both sexually and asexually. Before these facts were brought to light, it was impossible to explain how the fly which emerges from the currant-gall in June succeeded in surviving the winter and producing new galls in the spring, but it now appears that the spangle galls are carried down to the earth with the falling leaves, where they remain throughout the winter months, and from the impregnated eggs they contain, in due time the female brood emerges, which deposit their unimpregnated eggs in the currant-galls of spring. So far as known, this dimorphism is confined to the galls of Cynipidæ.

Irregular, egg-shaped swellings of a bright red colour on the leaves of willows are caused by a very common saw-fly, *Nematus gallicola*; but a much more familiar example is the mossy gall, or bedeguar of the wild rose. This gall, which is produced by a Cynipid (*Rhodites rosæ*), is an arrested leaf-shoot; only the vascular fibres of the leaves are developed, and it is to these the gall owes its mossy appearance. The russet and carmine tints of these fibres give the gall a very beautiful appearance. Internally it consists of a number of cells massed together, in each of which is a larva. Galls of this description which are made up of a number of compartments are termed polythalamous; those having but a single larval chamber are monothalamous. When inquilines take possession of a many-chambered gall they often convert it into a monothalamous one, besides distorting its shape. Galls at first are solid, but as the larva eats away the interior they become hollow. The grubs of many gall-flies complete their metamorphoses within the gall, from which they only emerge after attaining the winged condition; others again, when full fed, pierce a hole in the gall, through which they descend to the ground, where they pass the pupa stage of their existence. In the highly developed galls of the true gall-flies, as many as seven different layers or tissues may be distinguished; the central mass constituting the food of the larvæ, and the outer layers being protective in

unction. The coloration of galls is perhaps also protective in some cases. Protection is needed especially against birds, some of which break open galls to get at the grubs they contain.

Besides the bedeguar a red globular gall, that of *R. eglanteriæ*, is common on the leaves of the dog-rose, and all our native roses are galled by Cynipids. In these rose-galls species of Periclistus take up their quarters as inquilines; ichneumons may also be present as parasites.

The galls of *Andricus saliens* are known in California as "flea seeds," from their jumping about on the ground; this results from the spasmodic movements of the larva inside the thin-walled cavity of the gall. Another Californian gall has been described as covered with mobile hairs, which are sensitive to touch like the leaves of the mimosa. Very remarkable, too, is the relationship subsisting between the Cynipidæ and figs. Certain species of saw-fly deposit their eggs in the seed-vessels of the florets in the interior of the wild fig. When fully developed the saw-flies emerge, covered with pollen obtained from the male flowers near the opening of the fig. Following an ancient custom, the Greeks and Italians hang up bunches of the wild fruits on their cultivated fig trees, and the pollen-covered flies which escape from them enter the cultivated figs and fertilize the female florets in their interiors. This operation is known as caprification. The figs of the wild variety might almost be described as galls, since they serve as hatcheries for the saw-flies. Each species of fig would further appear to have its own special saw-fly. The Dead Sea fruit, or apples of Sodom, "which tempt the eye but turn to ashes on the lip," are probably galls on a species of oak produced by *Cynips insana*, though some suppose that the reference is to the fruit of a species of Asclepias.

We come now to the galls of the Cecidomyidæ. In this country one has not far to seek for them; just at present the galls of *Cecidomyia urticæ* are very abundant on the common nettle. They grow on different parts of the plant as irregular swellings, sometimes on the basal lobes of the leaf, often as irregular masses on the inflorescence. When opened, each cavity is seen to contain a single white larva.

On the umbels of the wild carrot, which is just now coming into fruit, here and there one may find a fruit enlarged to twice the ordinary size. Each loculus of the two-celled ovary is occupied by a single orange-coloured grub of Cecidomyia. Older galled fruits which have been vacated are also to be seen, with two little round holes at their base, through which the larvæ have made their exit. This species completes its metamorphosis outside the gall, but numbers of the gall-midges spin their cocoons within it, and only leave the gall as winged insects. Swollen stems and leaves are very common on the lady's bedstraw and other species of Galium. These yellowish-green galls are produced by the gall-midge *C. galli*. *C. campanula*, as its name indicates, gives rise to globular and ovate galls on the harebell (*Campanula rotundifolia*). Other midges gall the flower-buds of the whin and broom, the ovary of the violet, the catkins of the birch, the leaves of the ash and willow, the leaf-stalks of the poplar, and the fronds of the bracken. It would occupy too much space to enumerate all our native plants on which these dipterous galls occur. Such a list will be found in Prof. Trail's papers in the *Scottish Naturalist*. Suffice it to say that one has only to look for them to find them, since they are borne by a large proportion of our native wild flowers. The species of Cecidomyia are usually named from the plants from which their galls are obtained. The gall on *Veronica chamædrys*, mentioned at the beginning of this paper, is one of the commonest; it consists of an arrested terminal shoot with closely overlapping leaves. Externally it is reddish in colour and covered with grey hairs; within is a padding of hairs, and in the axil of each leaf a cell is formed containing the orange larva of the gall-midge *C. veronicæ*. Whether any inquilines have ever been noticed in it or not, we have not been able to ascertain, and the evidence afforded by the white larvæ is inconclusive, for Mr. F. Binnie states that the larvæ of *C. trifolii*, which galls the clover-leaf, are white when young but gradually change to orange at maturity. But as the number of larvæ in the gall was larger than usual, the probability that the white ones belonged to a different species from the orange ones is considerable. Be this as it may, the gall in question, according to Prof. Trail, is really a mite-gall, which is taken possession of by the gall-midges; and if this opinion be correct, then our white and orange larvæ, whether of the same species or not, both partook of the cuckoo character. The galls on the wild thyme are of a similar description, and are tenanted by the orange larvæ of *C. thymicola*.

The reader who desires to pursue this subject will do well to consult the article on galls in the "Encyclopædia Britannica"; Mr. Cameron's volumes in the Ray Society's "Proceedings" on the British Phytophagous Hymenoptera; Dr. Adler's recently translated "Essay on Oak Galls"; and the articles of Prof. Trail before mentioned, to which we have been indebted in the preparation of this paper.

THE FACE OF THE SKY FOR OCTOBER.

By Herbert Sadler, F.R.A.S.

SUNSPOTS and faculæ are still prevalent on the solar surface. The zodiacal light should be looked for before sunrise. Conveniently observable minima of Algol occur at 10h. 30m. P.M. on the 18th, and at 7h. 18m. P.M. on the 21st.

Mercury is not well situated for observation during October, as through the whole of the month he never sets much more than half an hour after the Sun.

Venus is still visible as a morning star, but is not very well placed for observation by the amateur, and her apparent diameter is rapidly decreasing. She rises on the 1st at 4h. 32m. A.M., or one hour and a half before the Sun, with a northern declination of 3° 36′, and an apparent diameter of $10\frac{1}{4}''$, $\frac{96}{100}$ths of the disc being illuminated. On the 7th she rises at 4h. 50m. A.M., or 1h. 22m. before the Sun, with a northern declination of 0° 39′, and an apparent diameter of 10″. On the 17th she rises at 5h. 22m. A.M., or 1h. 6m. before the Sun, with a southern declination of 4° 19′, and an apparent diameter of 10″. On the 31st she rises at 6h. 6m. A.M., or about three-quarters of an hour before the Sun, with a southern declination of 11° 1′, and an apparent diameter of $9\frac{3}{4}''$, $\frac{99}{100}$ths of the disc being illuminated. During the month she passes through nearly the whole of Virgo, being very near η Virginis on the 8th.

Mars is an evening star, and is excellently situated for observation, coming as he does into opposition with the Sun on the 20th. He is at his least distance from the earth (40,040,000 miles) on the 12th. On the 1st he rises at 6h. 32m. P.M., or 52m. after sunset, with a northern declination of 9° 36′, and an apparent diameter of 21·2″, the phase on the p limb being only 0 5″. On the 8th he rises at 6h. P.M., or 38m. after sunset, with a northern declination of 9° 16′, and an apparent diameter of 21·6″, the phase being imperceptible. On the 15th he rises at

5h. 25m. P.M., or 20m. after sunset, with a northern declination of 8° 52′, and an apparent diameter of 21·7″. On the 22nd he rises at 4h. 51m. P.M., as the Sun sets, with a northern declination of 8° 27′, and an apparent diameter of 21·3″, being now at his brightest (star magnitude —2·3). On the 31st he rises at 4h. 7m. P.M., with a northern declination of 8° 1′, and an apparent diameter of 20·4″. During October Mars describes a retrograde path from the confines of Cetus and Aries into Pisces, being about 20′ south of the 4½rd magnitude star 0 Piscium on the night of the 24th. At about 9h. 20m. P.M. on the 17th a 10½ magnitude star will be about ¼′ south of the planet's limb.

Jupiter is an evening star, and is becoming well placed for observation. On the 1st he rises at 9h. 23m. P.M., with a northern declination of 22° 59′, and an apparent diameter of 39¼″, the phase on the *p* limb amounting to 0·4″. On the 8th he rises at 9h. 1m. P.M., with a northern declination of 22° 59′, and an apparent diameter of 40·1″. On the 17th he rises at 8h. 28m. P.M., with a northern declination of 22° 58′, and an apparent diameter of 41¼″. On the 22nd he rises at 8h. 7m. P.M., with a northern declination of 22° 58′, and an apparent diameter of 41·9″. On the 31st he rises at 7h. 33m. P.M., or 3h. after sunset, with a northern declination of 22° 59′, and an apparent diameter of 43″, the phase amounting to 0·3″. During the month he is almost stationary in Gemini, a little to the N.E. of μ Geminorum. The following phenomena of the satellites occur while the Sun is 8° below and Jupiter 8° above the horizon:—On the 2nd an eclipse disappearance of the first satellite at 5h. 15m. 15s. A.M., a transit ingress of the shadow of the third satellite at 11h. 24m. P.M. On the 3rd a transit egress of the shadow of the third satellite at 2h. 0m. A.M., a transit ingress of the shadow of the first satellite at 2h. 32m. A.M., a transit ingress of the satellite itself at 3h. 51m. A.M., a transit ingress of the third satellite at 4h. 41m. A.M., a transit egress of the shadow of the first satellite at 4h. 47m. A.M., and an eclipse disappearance of the first satellite at 11h. 43m. 38s. A.M. On the 4th an occultation reappearance of the first satellite at 3h. 16m. A.M., and a transit egress of its shadow at 11h. 16m. P.M. At midnight on the 4th a 10½ magnitude star will be between the second satellite and the planet, 1·1′ *f* Jupiter's centre, almost on the parallel. On the 5th a transit egress of the first satellite at 0h. 36m. A.M.; at midnight a 10½ magnitude star will be between the third and fourth satellites. On the 6th a transit ingress of the shadow of the second satellite at 0h. 15m. A.M., its transit egress at 2h. 48m. A.M., and a transit ingress of the satellite itself at 2h. 54m. A.M. On the 8th an occultation reappearance of the second satellite at 0h. 32m. A.M. On the 10th a transit ingress of the shadow of the third satellite at 3h. 23m. A.M., and a transit ingress of the shadow of the first satellite at 4h. 26m. A.M. On the 11th an eclipse disappearance of the first satellite at 1h. 37m. 3s. A.M., and its occultation reappearance at 5h. 8m. A.M.; a transit ingress of the shadow of the first satellite at 10h. 54m. A.M. On the 12th a transit ingress of the first satellite at 0h. 12m. A.M., a transit egress of its shadow at 1h. 10m. A.M., and of the satellite itself at 2h. 28m. A.M.; its occultation reappearance at 11h. 36m. P.M. On the 13th a transit ingress of the shadow of the second satellite at 2h. 49m. A.M., its egress at 5h. 23m. A.M., a transit ingress of the satellite itself one minute later, and an occultation disappearance of the third satellite at 10h. 17m. P.M. On the 14th an occultation reappearance of the third satellite at 1h. 4m. A.M.; an eclipse disappearance of the second satellite at 9h. 55m. 23s. P.M. On the 15th an eclipse reappearance of the second satellite at 0h. 23m. 9s. A.M., its occultation disappearance at 0h. 27m. A.M., and its occultation reappearance at 3h. 3m. A.M. On the 18th an eclipse disappearance of the first satellite at 3h. 30m. 30s. A.M. On the 19th a transit ingress of the shadow of the first satellite at 0h. 48m. A.M., a transit ingress of the satellite itself at 2h. 3m. A.M., a transit egress of its shadow at 3h. 4m. A.M., of the satellite itself at 4h. 19m. A.M., and its eclipse disappearance at 9h. 58m. 51s. P.M. On the 20th an occultation reappearance of the first satellite at 1h. 27m. A.M., a transit ingress of the shadow of the second satellite at 5h. 24m. A.M., a transit egress of the shadow of the first satellite at 9h. 32m. P.M., and its transit egress at 10h. 46m. P.M.; an eclipse reappearance of the third satellite at 11h. 42m. 55s. P.M. On the 21st an occultation disappearance of the third satellite at 2h. 3m. A.M., and its reappearance at 4h. 51m. A.M. On the 22nd an eclipse disappearance of the second satellite at 0h. 31m. 4s. A.M., and its occultation reappearance at 5h. 32m. A.M. On the 23rd a transit egress of the shadow of the second satellite at 9h. 15m. P.M., and a transit egress of the satellite itself at 11h. 42m. P.M. On the 25th an eclipse disappearance of the first satellite at 5h. 24m. 1s. A.M. On the 26th a transit ingress of the shadow of the first satellite at 2h. 42m. A.M., of the satellite itself at 3h. 53m. A.M., a transit egress of its shadow at 4h. 58m. A.M., and an eclipse disappearance of the satellite at 11h. 52m. 23s. P.M. On the 27th an occultation reappearance of the first satellite at 3h. 16m. A.M., a transit ingress of its shadow at 9h. 10m. P.M., a transit ingress of the satellite itself at 10h. 20m. P.M., and a transit egress of its shadow at 11h. 26m. P.M. On the 28th a transit egress of the first satellite at 0h. 36m. A.M., an eclipse disappearance of the third satellite at 1h. 11m. 36s. A.M., its eclipse reappearance at 3h. 42m. 52s. A.M., its occultation disappearance at 5h. 45m. A.M.; an occultation reappearance of the first satellite at 9h. 43m. P.M. On the 29th an eclipse disappearance of the second satellite at 3h. 6m. 39s. A.M. On the 30th a transit ingress of the shadow of the second satellite at 9h. 16m. P.M., a transit ingress of the second satellite at 11h. 30m. P.M., a transit egress of its shadow at 11h. 50m. P.M. On the 31st a transit egress of the second satellite at 2h. 7m. A.M., and a transit egress of the third satellite at 10h. 33m. P.M. The following are the times of superior and inferior conjunctions of the fourth satellite with the centre of the planet:—Superior, October 9th, 1h. 36m. P.M.; October 26th, 6h. 30m. A.M. Inferior, October 17th, 10h. 34m. P.M.

Both Saturn and Uranus are invisible.

Neptune is an evening star, and is becoming well situated for observation. He rises on the 1st at 8h. 14m. P.M., with a northern declination of 21° 12′, and an apparent diameter of 2·6″. On the 31st he rises at 6h. 13m. P.M., with a northern declination of 21° 8′, and an apparent diameter of 2·7″. During October he pursues a retrograde path in Taurus, being very near the 4¾ magnitude star ι Tauri during the whole of the month. A map of the stars near his path will be found in the *English Mechanic* for September 7th, 1894.

October is a fairly favourable month for showers of shooting stars, the most marked display being that of the Orionids on the 18th, the radiant point being in VI.h. 8m. R.A., and + 15°.

The Moon enters her first quarter at 7h. 1m. P.M. on the 6th; is full at 6h. 41m. P.M. on the 14th; enters her last quarter at 6h. 56m. P.M. on the 21st; and is new at 5h. 57m. P.M. on the 28th. She is in apogee at 2h. A.M. on the 8th (distance from the earth 251,320 miles), and in perigee at 1h. P.M. on the 22nd (distance from the

earth 229,260 miles). At 6h. 3m. P.M. on October 7th the 5th magnitude star A Sagittarii will disappear at an angle of 1°, and reappear at 7h. 1m. P.M. at an angle of 323°. At 7h. 14m. P.M. on the 10th the 6th magnitude star 50 Aquarii will disappear at an angle of 30°, and reappear at 8h. 25m. P.M. at an angle of 264°; and at 11h. 11m. P.M. the 6½ magnitude star B.A.C. 7835 will disappear at an angle of 102°, and reappear at 11h. 58m. P.M. at an angle of 186°. At 2h. 45m. A.M. on the 15th the 6th magnitude star π Piscium will disappear at an angle of 36°, and reappear at 3h. 47m. A.M at an angle of 266°; and at 5h. 53m. P.M. the 6th magnitude star 19 Arietis will disappear at an angle of 113°, and reappear at 6h. 27m. P.M. at an angle of 193°. At 4h. 13m. A.M. on the 16th the 6th magnitude star 27 Arietis will disappear at an angle of 115°, and reappear at 4h. 58m. A.M. at an angle of 202°. At 5h. 27m. A.M. on the 17th the 6½ magnitude star 66 Arietis will disappear at an angle of 73°, and reappear at 6h. 31m. A.M. at an angle of 260°. At 3h. 5m. A.M. on the 18th the 5½ magnitude star χ^1 Tauri will make a near approach at an angle of 165°. At 0h. 34m. A.M. on the 18th the 6½ magnitude star B.A.C. 1648 will disappear at an angle of 45°, and reappear at 1h. 33m. A.M. at an angle of 289°. At 5h. 15m. A.M. on the 20th the 5½ magnitude star 59 Aurigæ will disappear at an angle of 93°, and reappear at 6h. 29m. A.M. at an angle of 282°.

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solutions of September Problems (F. H. Guest).

No. 1.—B to Q7.

Solved also by 1. K to Kt5.

Correct Solutions received from Chat and Crossgar (both solutions); J. E. Gore, W. H. Skelton, H. S. Brandreth, W. Willby.

No. 2.—Kt to Kt6.

Correct Solution received from Chat, W. Willby.

Additional solution of July Problem No. 1 received from E. Boustead.

W. H. Skelton.—In No. 2, after 1. B to Kt3, P to Kt5, 2. Kt to K6ch, K to B 3, there is no mate.

A. G. Fellows.—The family success in *Boys* Tournament is remarkable. We shall be glad to receive the problem composed with the Knowledge Prize set of men.

J. E. Gore.—Probably the diagrams you require could be obtained from the British Chess Company, 247, High Holborn. They usually cost about 1s. a hundred. Your last two problems suffer from the same evils of overcrowding and want of economy. No. 1 is quite spoilt by the *double threat*, which is only allowable when Black is *compelled* to avoid one of the threatened mates. The mates in this are also of little beauty, and some of the Pawns unnecessary. The other has two good mates with the Queen, but the problem would be much improved if you could abolish the Black Queen with its attendant Pawns, and also the Pawn at K7. It is not a bad plan for inexperienced composers to limit themselves to twelve or, at any rate, sixteen pieces. The best problems seldom have more.

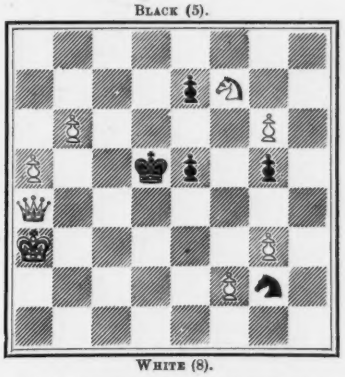
W. Willby.—The key is still weak, in that it moves a piece which is *en prise*, thereby depriving the Black King of half his liberty. Moreover, there is a bad dual after 1. . . P to K6, and also after several moves of the Black Queen. This last piece should be got rid of, as it leads to no fresh mate. It should be possible to get the four variations which you aim at by employing ten or, at most, twelve pieces.

R. Kelly.—Thanks for the problems. We shall be glad to insert the block problem in the November number. The three threat problems do not seem very happily constructed as regards economy of force. Many of the pieces do scarcely any work.

PROBLEM.

By B. G. Laws.

Black (5).



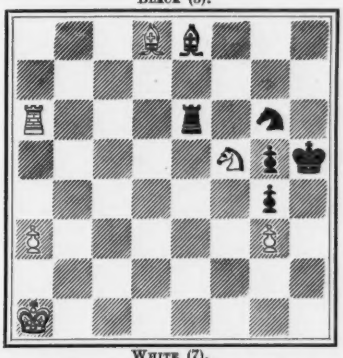
White (8).

White mates in three moves.

CONDITIONAL PROBLEM.

By W. De Morgan.

Black (5).



White (7).

White mates in three moves.

[On condition that when a Rook moves it becomes a Knight, and *vice versa*.]

The following game was played in the fifth round of the Leipsic International Tournament, between M. Janowsky, of Paris, and Mr. R. Teichmann, of London.

"French Defence."

White (M. Janowsky).	Black (Mr. Teichmann).
1. P to K4	1. P to K3
2. P to Q4	2. P to Q4
3. Kt to QB3	3. Kt to KB3
4. B to Kt5	4. B to K2
5. P to K5	5. KKt to Q2
6. B × B	6. Q × B

7. Kt to QKt5 (*a*)	7. Q to Qsq (*b*)
8. P to QB3 (*c*)	8. P to QR3
9. Kt to QR3	9. P to QB4
10. P to KB4	10. Kt to QB3
11. Kt to KB3	11. P to B5 (*d*)
12. Kt to QB2	12. P to QKt4
13. B to K2 (*e*)	13. P to QR4
14. Castles	14. Castles (*f*)
15. Kt to K3	15. Q to Kt3
16. Q to Q2 (*g*)	16. P to KB4
17. B to Qsq	17. P to Kt5
18. B to B2	18. P to QR5
19. P to QR3 (*h*)	19. P × BP (?)
20. P × P	20. Q to B2
21. P to KKt4 !	21. P to KKt3
22. Q to Kt2	22. K to Rsq
23. Kt to KKt5	23. Kt to QKt3 (*i*)
24. R to B3	24. Q to KKt2
25. R to QKtsq (*j*)	25. R to QR3
26. P × P	26. KtP × P
27. R to KKt3	27. Q to K2
28. R to KR3	28. R to KKtsq
29. K to Rsq	29. R to KKt2
30. QR to KKtsq	30. Q to KBsq (*k*)
31. Kt × RP (*l*)	Resigns

Notes.

(*a*) A move which has grown in favour of late years. The old continuation was 7. Q to Q2, P to QR3 ; 8. Kt to Qsq, in order to be able to meet 8 . . . P to QB4 by 9. P to QB3, the Knight ultimately finding a good square at K3.

(*b*) 7. . . . Kt to KBsq is the usual and better move.

(*c*) For now White should gain some advantage by 8. Q to KKt4. The omission of this move has been frequently noticed in this column. When possible it is nearly always a formidable move. In the present instance, if met by 8. . . . Castles, 9. B to Q3 would give White some attack ; while 8. . . . P to KKt3, 9. P to KR4 (!), would be good for White.

(*d*) The previous three moves on each side form the usual stereotyped procedure ; here it is customary to play 11. . . . P to QKt4, followed perhaps by Q to Kt3, thereby maintaining the pressure on the White QP.

(*e*) Owing to his omission on the eighth move, White's game is now rather cramped. If he play 13. P to QR4, Black might simply take the P, in order to attack subsequently the weakened QKtP.

(*f*) It was not necessary to commit himself by castling yet, as the King's Rook cannot be utilized at present. 14. . . . P to Kt5 seems preferable.

(*g*) Obviously if 16. P to B5, KKt × P. Hence Black's last move—and his next. White's next move is with a view to B to B2 and ultimately P to KKt4.

(*h*) White could not allow P to R6. Black's reply is very weak. 19. . . . P to Kt6 would be both immediately cramping and likely to prove useful in an end-game. With the White King out of reach there would be the chance of sacrificing a piece for the QBP or QRP in order to Queen the advanced KtP. As it is, White has his Bishop left on an attacking square, and speedily gets the better of the game.

(*i*) Apparently best. 23. . . . Kt to Qsq would give White too many sacrificial opportunities shortly. On his next move R to R2 seems more to the point.

(*j*) Finely played. He cleverly renders Black's QR inactive before proceeding to demolish him.

(*k*) There seems to be no defence. If, for instance, 30. K to Ktsq, R × RP wins.

(*l*) Prettily played. If now 31. . . . R × Q, 32. Kt to B6ch leads to a speedy mate, or if 31. . . . R × Kt, 32. R × Rch, K × R ; Q to Kt6ch, etc. M. Janowsky played the ending with his customary vigour.

CHESS INTELLIGENCE.

The International Tournament of the German Chess Association, held this year at Leipsic, was brought to a conclusion on September 15th. The result was a victory for Dr. Tarrasch, who thus won his fourth consecutive International Tourney, but this time only by the narrow majority of half a point. He lost games to Blackburne, to Mieses, through a blunder, and, apparently, also to Lipke in the last round. The prize-winners were :—1. Tarrasch (Nüremburg), 13½ ; 2. Lipke (Berlin), 13 ; 3. Teichmann (London), 12½ ; 4. Blackburne (London) and Walbrodt (Berlin), 11½ ; 6. Marco (Vienna) and Janowsky (Paris), 10½. The remaining competitors came out in the following order :—Berger, Shiffers, Schlechter, Mieses, Baird, Süchting, Zinkl, Weydlich, Mason, Seuffert and V. Scheve (retired). Mr. Mason's performance is most disappointing. On the other hand, Mr. Blackburne played well after a bad start, while M. Teichmann by his excellent performance showed that his two consecutive victories in the Divan Tournaments represent his true form. In the absence of Lasker, Tschigorin, Gunsberg, Bardeleben, Makovez, Winawer and others, the competitors cannot, of course, be regarded as representative of the chess talent of Europe. Still, the winner has maintained his reputation, and Lipke, Teichmann and Janowsky have certainly increased theirs. As at Dresden, Walbrodt and Marco were extremely difficult to beat, while Berger was as usual generally both willing and able to draw.

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